KAVAYITRI BAHINABAI CHAUDHARI

NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Third Year Engineering

(Chemical Engineering)

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
3rd Cycle

SYLLABUS

Semester – V

W.E.F. 2020 – 21

Syllabus Structure for Third Year Engineering (Semester – V) Chemical Engineering (w.e.f. 2020 – 21)

Name of the Course	Group	Teaching Scheme				Evaluation Scheme					Credits
						Theory		Practical		Total	
		Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE	ESE	ICA	ESE		
Mass Transfer-I	D	3	-	-	3	40	60	-	-	100	3
Chemical Reaction Engineering-I	D	3	-	-	3	40	60	-	-	100	3
Particle and Fluid-Particle Processing	D	3	-	-	3	40	60	-	-	100	3
Professional Elective Course – I	E	3	-	-	3	40	60	-	-	100	3
Open Elective Course – I	F	3	-	-	3	40	60	-	-	100	3
Mass Transfer-I Lab	D	-	-	2	2	-	-	25	25 (PR)	50	1
Chemical Reaction Engineering-I Lab	D	-	-	2	2	-	-	25	25 (OR)	50	1
Chemical Engineering Lab-III	D	-	-	2	2	-	-	25	25 (OR)	50	1
Minor Project (Stage - I)	G	-	-	6	6	-	-	50	-	50	3
Constitution of India	H	-	-	-	-	-	-	-	-	-	-
		15	**0**	**12**	**27**	**200**	**300**	**125**	**75**	**700**	**21**

ISE: Internal Sessional Examination ESE: End Semester Examination ICA: Internal Continuous Assessment

Professional Elective Course – I	Open Elective Course – I
Process Equipment Design	Energy Engineering
Advance Catalysis	Environmental Engineering
Polymer Science and Engineering	Biochemical Engineering
Intellectual Property Rights	Thermal Engineering

Syllabus Structure for Third Year Engineering (Semester – VI)Chemical Engineering (w.e.f. 2020 – 21)

Name of the Course	Group	Teaching Scheme				Evaluation Scheme					Credits
						Theory		Practical		Total	
		Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE	ESE	ICA	ESE		
Mass Transfer-II	D	3	-	-	3	40	60	-	-	100	3
Chemical Reaction Engineering-II	D	3	-	-	3	40	60	-	-	100	3
Heat Transfer	D	3	-	-	3	40	60	-	-	100	3
Professional Elective Course – II	E	3	-	-	3	40	60	-	-	100	3
Open Elective Course – II	F	3	-	-	3	40	60	-	-	100	3
Mass Transfer-II Lab	D	-	-	2	2	-	-	25	25 (PR)	50	1
Chemical Reaction Engineering-II Lab	D	-	-	2	2	-	-	25	25 (OR)	50	1
Heat Transfer Lab	D	-	-	2	2	-	-	25	-	25	1
Minor Project	G	-	-	6	6	-	-	50	25 (OR)	75	3
Internship - II*	H	-	-	-	-	-	-	-	-	-	-
		15	**0**	**12**	**27**	**200**	**300**	**125**	**75**	**700**	**21**

ISE: Internal Sessional Examination ESE: End Semester Examination ICA: Internal Continuous Assessment

Professional Elective Course – II	Open Elective Course – II
Instrumentation & Instrumental Analysis	Alternative Fuels
Numerical Methods in Chemical Engineering	Electrochemical Engineering
Oil Technology	Solid Waste Management
Interfacial Engineering	Biotechnology

* Internship - II is a mandatory and non-credit course. It shall be during summer vacation after Semester – VI. The satisfactory completion of Internship should be submitted to University at the end of Semester – VIII.

Mass Transfer-I					
COURSE OUTLINE					
Course Title:	**Mass Transfer-I**	**Short Title:**	**MT-I**	**Course Code:**	

Course description:

This course describes fundamental aspects of Mass Transfer operations, Mass Transfer theories and Mass transfer with phase change. The objective of the course is to apply the principles learned in science and engineering courses to the design of equipment for physical transformations, to design new processes and optimize existing processes.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Chemistry, Industrial Chemistry, Thermodynamics-I & II, Fluid Mechanics, Material and Energy Balance Computations.

Course objectives:

1. To understand the mass transfer operations and modes of mass transfer.
2. To learn eddy (turbulent) diffusion, relation between mass transfer coefficients.
3. To design equipments for gas liquid operation.
4. To accustom cooling towers.
5. To understand gas liquid equilibrium, various gas liquid contactors and different type of crystallizers.

Course outcomes:

After successful completion of this course the student will be able to:

1. Learn about the basics of the mass transfer process.
2. Understand diffusion phenomenon in solids and fluids.
3. Demonstrate knowledge of mathematics, science and engineering principles.
4. Providing a sound process design of various equipments used in humidification, gas absorption/stripping, crystallization and drying operation.
5. Identify, formulate, design and provide the solution to various chemical engineering problems.

COURSE CONTENT

Mass Transfer-I		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to mass transfer operations, classification of mass transfer operations, diffusivity, Fick's law of diffusion.

Steady state molecular diffusion in fluid at rest, molecular diffusion in gases and liquids, multicomponent mixture diffusion, Maxwell's law of diffusion, diffusion in solids, unsteady state mass transfer.

Unit–II:	No. of Lectures: 09 Hours	Marks: 12
Eddy (turbulent) diffusion, relation between mass transfer coefficients. Mass transfer coefficient in laminar and turbulent flow, theories of mass transfer, Equilibrium for mass transfer process: Local two phase mass transfer, Local overall mass transfer coefficient, Use of local overall coefficient.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Equipments for gas liquid operation. Material balances for steady state co current, countercurrent, cross flow cascade, counter flow cascade. Introduction to humidification: vapor liquid equilibrium, humidification terms, Determination of humidity, humidification and dehumidification, cooling towers.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Introduction to gas absorption operation, equilibrium solubility of gases in liquids. Material balance for one component transferred in countercurrent flow and co current flow, countercurrent multistage operation, one component transferred. Absorption with chemical reaction. Different absorption operation equipments (plate tower, packed tower, venture scrubber).		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Introduction to crystallization, Growth and properties of crystals, Effect of impurities in crystallization, Effect of temperature on solubility, Fractional crystallization, Caking & yield of crystals, Different type of crystallizers. Introduction to drying operation, rate of drying, mechanism of moisture movement during drying, drying equipments, different methods of drying.		

Text Books:

1. Coulson & Richardson Chemical Engineering (Vol. I & Vol. II), Butterworth-Heinmann (Elsevier) (Sixth Edition & Fifth Edition).
2. R. E. Treybal, Mass transfer operation, McGraw Hill Book Company, (Third Edition).

Reference Books:

1. Christie J. Geankoplis, Transport Processes & Unit Operations, Prentice Hall Inc.
2. Coulson & Richardson Chemical Engineering (Vol.IV), Butterworth-Heinmann (Elsevier).
3. Coulson & Richardson Chemical Engineering (Vol.V), Butterworth-Heinmann (Elsevier).

Chemical Reaction Engineering-I					
COURSE OUTLINE					
Course Title:	**Chemical Reaction Engineering-I**	**Short Title:**	**CRE-I**	**Course Code:**	

Course description:

This course applies the concepts of reaction rate, stoichiometry and equilibrium to the analysis of chemical reacting systems. It derives rate expressions from reaction mechanisms and equilibrium or steady state assumptions, design of chemical reactors via synthesis of chemical kinetics, mass and energy balances.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Chemistry, Industrial Chemistry, Thermodynamics-I & II, Fluid Mechanics, Material and Energy Balance Computations.

Course objectives:

1. To become accustomed to the chemical reaction, rate of reaction, order, molecularity of reaction, rate constant, the activation energy and temperature dependency of rate equation.
2. To use methods for demonstrating the skill about analysis of constant volume batch reactor and variable volume batch reactor and the integral and differential method.
3. To interpret the ideal batch reactor, mixed flow reactor and plug flow reactor.
4. To understand about the reaction in parallel, series, Series parallel reaction and the optimum temperature progression for single reaction, Isothermal, adiabatic, non adiabatic operation.
5. To learn the residence time distribution of fluid in vessel and concepts of micro and macro mixing.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the basic concepts of chemical reaction engineering.
2. Compare various reactors.
3. Understand the Optimum temperature progression for single reaction, Isothermal, adiabatic, non adiabatic operation.
4. Know the residence time distribution of fluid in vessel & concept of micro and macro mixing.
5. Identify related calculation and solutions to chemical reaction engineering problems for designing chemical reactors.

COURSE CONTENT

Chemical Reaction Engineering-I		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to chemical reaction engineering: Review of chemical reaction equilibrium,

Classification of chemical reaction, rate of reaction, order and molecularity of reaction, rate constant, Temperature dependent term of rate equation, comparison of theories, Activation energy and temperature dependency, rate of reaction predicted by theories, Reaction mechanism.

Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**

Collection & interpretation of kinetic data, Constant volume batch reactor, integral and differential method of analysis of data, Variable volume batch reactor, integral and differential method of analysis of data, The search for rate equation.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Ideal batch reactor, mixed flow reactor, plug flow reactor, space time and space velocity, holding time and space time for batch, mixed and plug flow reactors, comparison in mixed and plug flow reactors, Combined flow system, Recycle reactor, Autocatalytic reaction.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Introduction to multiple reactions: Reaction in parallel, Reaction in series, Series parallel reaction. Optimum temperature progression for single reaction, Isothermal, adiabatic, non adiabatic operation, Product distribution and temperature for multiple reactions.

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Residence time distribution of fluid in vessel, Conversion directly from tracer information, Models for non-ideal flow, Dispersion models, Tank in series model, Concept of micro and macro mixing.

Text Books:

1. Octave Levenspiel, Chemical Reaction Engineering, John Wiley and Sons.
2. H.Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall New Jersey.

Reference Books:

1. Coulson & Richardson Chemical Engineering (Vol. III), Butterworth-Heinmann (Elsevier) (Sixth Edition).
2. Coulson & Richardson Chemical Engineering (Vol. V), Butterworth-Heinmann (Elsevier) (Sixth Edition).
3. S.D. Dawande, Principles of Reaction Engineering, Denett & Co., Nagpur.
4. Lanny D. Schimdt, Chemical Reaction Engineering, Oxford University Press.
5. J. M. Smith, Chemical Engineering Kinetics, McGraw Hill

Particle and Fluid-Particle Processing					
COURSE OUTLINE					
Course Title:	**Particle and Fluid-Particle Processing**	**Short Title:**	**PFPP**	**Course Code:**	

Course description:

This course is an introduction to fluid flow and particle mechanics with an emphasis on fundamental concepts and applications in process industries. Examples and applications will generally cover fluid machinery, pipe flow and fluid-particle systems.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Chemistry, Industrial Chemistry, Thermodynamics-I & II, Fluid Mechanics, Material and Energy Balance Computations.

Course objectives:

1. To understand the Solid particle characterization.
2. To learn the types of fluidization and applications.
3. To accustom about the sedimentation.
4. To evaluate design of bag filters, electrostatic filters, cyclones and hydrocyclones.
5. To interpret the size reduction operation.

Course outcomes:

After successful completion of this course the student will be able to:

1. Analyze solid particle characterization.
2. Know the types of fluidization and its applications.
3. Analyze filtration data and select filtration equipments.
4. Calculate drag force and terminal settling velocity for single particles.
5. Demonstrate size enlargement; nucleation and growth of particles.

COURSE CONTENT

Particle and Fluid-Particle Processing		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction: Relevance of fluid and particle mechanics, and mechanical operations, in Chemical engineering processes.

Solid particle characterization: Particle size, shape and their distribution; Relationship among shape factors and particle dimensions; Specific surface area; Measurement of surface area.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Flow around immersed bodies: Concept of drag, skin and form drag, drag correlations

Packed bed: Void fraction, superficial velocity, channeling, Ergun equation and its derivation,

Darcy's law and permeability, Blaine's apparatus

Unit–III:	No. of Lectures: 09 Hours	Marks: 12

Fluidization: Fluidized bed, pressure drop, Geldart plot etc. Types of fluidization: Particulate fluidization, Bubbling fluidization, Classical models of fluidization, Circulating fluidized beds, Applications of fluidization
Separation of solids from fluids: Introduction
Sedimentation: Free Settling, hindered settling, Richardson-Zaki equation, design of settling tanks

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Filtration: Concepts, design of bag filters, design of electrostatic filters
Centrifugal separation, design of cyclones and hydrocyclones
Size reduction, milling, laws of comminution, classification of particles

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Size enlargement; Nucleation and growth of particles
Transport of fluid-solid systems: pneumatic and hydraulic conveying
Colloidal particles: stabilization, flocculation
Introduction to nanoparticles: Properties, characterization, synthesis methods, applications

Text Book:

1. McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, sixth edition, McGraw Hill.
2. P. Chattopadhya, Unit Operations of Chemical Engineering, Khanna Publishers.

Reference Books:

1. Rhodes, M. J., Introduction to Particle Technology, second edition, John Wiley, Chichester, New York, 2008.
2. Allen, T., Powder Sampling and Particle Size Determination, Elsevier, 2003.
3. Masuda, H., Higashitani, K., Yoshida, H., Powder Technology Handbook, CRC, Taylor and Francis, 2006.
4. Vollath, D. Nanomaterials: An Introduction to Synthesis, Properties and Applications, second edition, Wiley, 2013.
5. Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.

Professional Elective Course – I					
Process Equipment Design					
COURSE OUTLINE					
Course Title:	**Process Equipment Design**	**Short Title:**	**PED**	**Course Code:**	

Course description:

This course describes to use appropriate terminology of process equipment preliminaries and design. It illustrates basic functions of process equipment; and relates scientific principles associated with process equipment design.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Engineering Graphics, Industrial Chemistry, Material Science, Material and Energy Balance Computations.

Course objectives:

1. To learn the design preliminaries and the mechanical design of heads.
2. To evaluate the process equipment design of storage vessel and the mechanical design of support for vessels.
3. To understand the process equipment design of cylindrical vessel using external pressure, shell and tube heat exchanger and calendria type evaporator.
4. To apply knowhow for design of reaction vessel, the process design of crystallizers and design of rotary dryer.
5. To demonstrate skill of the process design of thick wall high pressure vessel and the mechanical design of turbine agitator.

Course outcomes:

After successful completion of this course the student will be able to:

1. Exhibit design skills in chemical process industry and in a competitive manner how to design Heads, storage vessel, support for vessels, cylindrical vessels under external pressure, shell and tube heat exchanger, calendria type evaporator, reaction vessel, crystallizers, rotary dryer, thick wall high pressure vessel and turbine agitator.
2. Demonstrate the ability to perform the task by identifying, formulating, designing and providing the solution to various chemical engineering problems.
3. Identify, formulate, design and provide the solution to various chemical engineering problems.
4. Understand professional and ethical responsibilities formally and informally show the capacity of designing the product to meet economical and societal requirements.
5. Understand about the environmental issues and will provide solutions for green and clean technologies.

COURSE CONTENT

Process Equipment Design		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60**

			marks
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

Design Considerations: Design codes, Maximum working pressure, Design pressure, Design Temperature, Design stress, Factor of safety, Selection of factor of safety, Design wall thickness, Corrosion ratio, Poisson ratio, Criteria of failure, Elastic stability.
Design of Cylindrical Vessels under internal Pressure: Introduction, Thin wall vessels, Design Equations.
Design of Heads: Introduction, Analysis and design of conical head, Flat cover head, Standard dished heads.

Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**

Storage vessels: Introduction, Design of fixed conical roof cylindrical tank, Storage of gases in Spherical vessels.
Supports for vessels: Introduction of Bracket or Lug supports, Leg supports and Saddle Support.
Design of process vessels and pipes under external pressure: Introduction, Determination of safe pressure against elastic failure, Determination safe external pressure against plastic deformation, circumferential stiffness, Pipes and tubes under external pressure

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Process Design of Heat Exchanger: Introduction, Types of Heat Exchanger, Process Design of Shell and Tube Heat Exchanger.
Process Design of Evaporator: Introduction, Types of Evaporator, Methods of Feeding of Evaporator, Design of Calendria type Evaporator.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Process Design of Reaction Vessels: Introduction, Materials of Construction, Agitation, Classification of Reaction Vessels, Heating Systems, Design of Reaction Vessel.
Crystallizer Design: Introduction, Types of Crystallizers, Design of crystallizers.

Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**

Process Design of Rotary Dryer: Introduction, Types of Dryer, Design of Rotary Dryer.
Design of Thick Walled High Pressure Vessel
Agitators: Introduction, Types of Agitators, Baffling, Power Requirements, Design of Turbine Agitator

Text Books:

1. B.C. Bhattacharya, Introduction to Chemical Equipment Design (Mechanical Aspects), CBS Publisher and Distributors, New Delhi.
2. M.V. Joshi, V.V. Mahajani Process Equipment Design, Macmillan Publishers India Ltd. (Fourth Edition).

Reference Books:

1. S.D. Dawande, Process Equipment Design (Vol. I),Denett & Co., Nagpur.
2. R. S. Khurmi, J.M. Gupta, A Text Book of Machine Design, S. Chand & Company Ltd, New Delhi.
3. Coulson & Richardson Chemical Engineering (Vol. VI), Butterworth-Heinmann (Elsevier)

(Sixth Edition).

Professional Elective Course – I

Advance Catalysis

COURSE OUTLINE

Course Title:	**Advance Catalysis**	**Short Title:**	**AC**	**Course Code:**	

Course description:

This course describes to use appropriate terminology of application of advance catalysis for possible commercialization of chemical processes. It illustrate show a chemical engineer is able to use his know how in development of chemical processes using advance catalysis.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Chemistry, Industrial Chemistry, Thermodynamics-I & II, Fluid Mechanics, Material and Energy Balance Computations.

Course objectives:

1. To accustom about the Homogeneous and Heterogeneous Catalysis, Catalyst Components and Catalyst treatment.
2. To evaluate the design, development and applications of Supported Catalysts.
3. To learn the regeneration of catalyst in Fluid Catalytic Cracking Unit.
4. To understand about the Catalysis in Petroleum and Petrochemical Industries.
5. To study the Introduction, Importance and Types of biocatalysts.

Course outcomes:

After successful completion of this course the student will be able to:

1. Demonstrates capability to study heterogeneous catalysis, kinetics of elementary steps, overall reactions, and evaluation of kinetic parameters with the tools, skills and knowledge
2. Apply advanced reactive systems analysis.
3. Do the technical and economic evaluation of chemical processes and operations.
4. Develop the ability of students to apply the theory of catalysis to various chemical industries.
5. Understand about the environmental issues and will provide solutions for green and clean technologies.

COURSE CONTENT

Advance Catalysis		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Catalysis: Introduction, History.

Homogeneous Catalysis: Introduction, Characterization of solution Processes, Examples of solution catalysis: Acid – base catalysis, Organometallic Catalysis.
Heterogeneous Catalysis: Introduction, Characterization of Surface Processes, Properties of Solid Catalysts, Influence of Mass Transport on Catalyst Performance.
Catalyst Components: Catalytically active species, Supports, Binders, Promoters.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Supported Catalysts: Introduction, Definition of Supported Catalysts. Advantages of Supported Catalysts: Separability, Cost, Catalyst activity, Catalyst Selectivity.
Support Materials for the Catalyst, Composition, Size and Shape, Surface Area., Porosity and Pore size. Attrition Loss, Density, Cost and quality.
Design and Development of Supported Catalysts: Preparation and Manufacture, Catalyst Preparation Methods, Catalysts from Physical Mixtures, Impregnated Catalysts, Ion exchange Catalysts. Testing and evaluation of Supported Catalysts, Application of Supported Catalysts.

Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**

Regeneration of Catalysts:
Fluid Catalytic Cracking Unit: Process Description, Heat Balance, Coke formation, Coke burning, CO Combustion, Environmental aspects. Regenerator Operating Parameters. Influence of Regenerator design on Catalyst Fluidization, Equipment/Unit Operation in Cracking Units.
Noble and Base Metal Catalysis: Noble Metal Catalysis, Deactivation, Regeneration, Regeneration Processes such as continuous Catalyst Regeneration, Fixed Bed Semi Regenerative Process, Cyclic or swing, Reactor for regeneration. Base Metal Catalysis: Process and Catalyst Description.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Catalysis in Petroleum and Petrochemical Industries:
Applications of zeolites in Petrochemical Refining. Improving quality of Petroleum fuels through Catalysis. O-xylene isomerization over Nickel containing SAPO-5 molecular sieves. Pd-sulfonated Polysiloxane catalyst for etherification of FCC light gasoline. Oxidation of Ethylbenzene catalyzed by Soluble Cobalt (III) complexes. Comparative evaluation of various catalysts used for removal of NO_x from air streams.

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Biocatalysts: Introduction and importance of biocatalysts. Type of biocatalysts.
Enzymes: Definition, Sources of Enzymes, production of Enzymes. Formation of enzyme substrate complex. Applications.
Simple enzyme kinetics. Derivation of Michaelis Menten equation. Evaluation of parameters of Michaelis Menten equation. Effect of Temperature and pH on enzyme Kinetics.
Microbial Cell: Classification of cells. Requirement for the growth of cells and growth Media.

Text Book:

1. Bhattacharya KG and Talukdar A K, Catalysis in Petroleum and Petrochemical Industries. Narosa Publishing House, New Delhi.
2. James E. Bailey and David F. Ollis, Biochemical Engineering Fundamentals; McGraw Hill Publication.

Reference Books:

1. Kirk Othmer, Encyclopedia of Chemical Technology, 4th edition, Volume-V. John Wiley and sons New York.
2. Richardson J.F. and Peacock D.G. Richardson and Coulson's, Chemical Engineering, Volume-III, Asian Books Pvt. Ltd., New Delhi.

Professional Elective Course – I

Polymer Science and Engineering

COURSE OUTLINE

Course Title:	**Polymer Science and Engineering**	**Short Title:**	**PSE**	**Course Code:**	

Course description:

The main objective of this course is to equip students with scientific knowledge and technical skills that are in line with current advancements in the field of polymer and related industries

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Chemistry, Industrial Chemistry, Thermodynamics-I & II, Fluid Mechanics, Material and Energy Balance Computations.

Course objectives:

1. To introduce basics of polymer science and technology.
2. To learn the importance of molecular weight of polymers & its determination.
3. To study the glass transition temperature & its relation with molecular weight of polymers.
4. To learn different thermal analysis techniques & mechanical properties of polymers.
5. To be familiar with the different polymer processing techniques.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the significance of molecular weight and its reflection in properties of polymers.
2. Identify significance of thermal analysis techniques in polymer technology.
3. Apply fundamental aspects of polymer science and engineering both from an academic and an industry point of view.
4. Display the ability to utilize different polymer processing techniques in manufacturing of desired polymeric based articles.
5. Demonstrate the ability to estimate the number- and weight-average molecular masses of polymer samples.

COURSE CONTENT

Polymer Science and Engineering		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to polymers and their classification, functionality, oligomer, polymer, repeating units, Types of polymerization. Addition Polymerization, Condensation Polymerization. Mechanism of polymerization. Bulk, solution, suspension and emulsion polymerization techniques. Co-polymerization.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12
Molecular weight & degree of polymerization, Significance of molecular weight of polymers, Average molecular weight and molecular weight distribution in polymers, measurements of number, average by Cryoscopy; Ebulliometry, Membrane osmometry, Vapor pressure osmometry and End group analysis. Measurement of viscosity, average molecular weight by viscometry.		
Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**
Glass transition temperature, Factors influencing glass transition temperature, Glass transition temperature & molecular weight, Glass transition temperatures & plasticizers. Thermal analysis of polymer by differential scattering calorimeter; TGA, TMA and HDT. Mechanical properties like tensile strength, Young's Modulus, hardness, etc.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Polymer processing& techniques, Compounding, Calendaring, Die casting, Rotational casting, Film casting, Injection moulding, Blow moulding, Extrusion moulding, Thermoforming, Foaming.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Properties, applications and manufacturing techniques of Polyethylene, Polypropylene, PVC, Phenol formaldehyde, Urea formaldehyde, Epoxy polymers, Styrene-Butadiene rubber (SBR), Nylon-6, 6, Viscose Rayon.		

Text Book:

V. R. Gowarikar, N. V. Vishwanathan, JaydevSreedhar, Polymer Science; New Age International (P) Limited, New Delhi.

Reference Books:

1. B. K. Sharma, Polymer Science, Goel Publishing House; Meerut.
2. Malcolm P. Stevens, Polymer chemistry, Oxford University press.
3. Fried W. Billmeyar, Text book of polymer science, John Willey and Sons.
4. M. Gopalarao, Dryden's Outlines of Chemical Technology; Third edition; East West Press.

Professional Elective Course – I					
Intellectual Property Rights					
COURSE OUTLINE					
Course Title:	**Intellectual Property Rights**	**Short Title:**	**IPR**	**Course Code:**	

Course description:

This course is introduced for learning the basic fundamentals of Intellectual property rights and Entrepreneurship to undergraduate students. The goals of the course are to understand the basic knowledge of intellectual property rights, trademarks, chemical safety & chemical ethics and entrepreneurship.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

English, Project Management and Entrepreneurship.

Course objectives:

1. To understand Introduction and the need for intellectual property right (IPR) and Macro economic impact of the patent system.
2. To learn searching a patent, Drafting of a patent, Filing of a patent.
3. To accustom related rights and copyright and Trademarks.
4. To know Geographical Indications and Industrial Designs.
5. To apply Research and Intellectual Property Rights Management, Licensing and Enforcing Intellectual Property.

Course outcomes:

After successful completion of this course the student will be able to:

1. To choose which type of IPR they should apply for.
2. Understand various ethical issues regarding the field and Aspects of Studying Intellectual Property Rights.
3. Do the technical and economic evaluation.
4. Develop the ability of students to apply the theory.
5. Demonstrate the understanding of professional and ethical responsibilities.

COURSE CONTENT

Intellectual Property Rights		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Overview of Intellectual Property: Introduction and the need for intellectual property right (IPR), IPR in India – Genesis and Development, IPR in abroad, some important examples of IPR Patents: Macro economic impact of the patent system, Patent and kind of inventions protected by a patent, Patent document, How to protect your inventions? Granting of patent, Rights of a patent, How extensive is patent protection? Why protect inventions by patents?

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Searching a patent, Drafting of a patent, Filing of a patent, The different layers of the international patent system (national, regional and international options), Utility models, Differences between a utility model and a patent? Trade secrets and know - how agreements.
Copyright- What is copyright? What is covered by copyright? How long does copyright last? Why protect copyright?
Related Rights - What are related rights? Distinction between related rights and copyright? Rights covered by copyright?

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Trademarks: What is a trademark? Rights of trademark? What kind of signs can be used as trademarks? Types of trademark, Function does a trademark perform, How is a trademark protected?
How is a trademark registered? How long is a registered trademark protected for? How extensive is trademark protection? What are well-known marks and how are they protected? Domain name and how does it relate to trademarks?
Geographical Indications: What is a geographical indication? How is a geographical indication protected? Why protect geographical indications?

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Industrial Designs: What is an industrial design? How can industrial designs be protected? What kind of protection is provided by industrial designs? How long does the protection last? Why protect industrial designs?
New Plant Varieties: Why protect new varieties of plants? How can new plants be protected? What protection does the breeder get? How long do the breeder's rights last? How extensive is plant variety protection?
Unfair Competition: What is unfair competition? Relationship between unfair competition and intellectual property laws?
Enforcement of Intellectual Property Rights: Infringement of intellectual property rights. Enforcement Measures

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Intellectual Property: Overview of Intellectual Property, Research and Intellectual Property Rights Management, Licensing and Enforcing Intellectual Property, Commercializing Invention, Case studies of patents.

Text Book:

T. M Murray and M.J. Mehlman, Encyclopedia of Ethical, Legal and Policy issues in Biotechnology, John Wiley & Sons 2000.

Reference Books:

1. P.N. Cheremisinoff, R.P. Ouellette and R.M. Bartholomew, Biotechnology Applications and Research, Technomic Publishing Co., Inc. USA, 1985.
2. D. Balasubramaniam, C.F.A. Bryce, K. Dharmalingam, J. Green and K. Jayaraman, Concepts in Biotechnology, University Press (Orient Longman Ltd.), 2002.
3. Bourgagaize, Jewell and Buiser, Biotechnology: Demystifying the Concepts, Wesley Longman, USA, 2000.
4. Ajit Parulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications;

Macmillan India ltd, 2006.
5. B.L.Wadehra; Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000.
6. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010.

Open Elective Course – I					
Energy Engineering					
COURSE OUTLINE					
Course Title:	**Energy Engineering**	**Short Title:**	**EE**	**Course Code:**	

Course description:

Energy engineering aims to give students real-world technical expertise in strategic renewable energy disciplines, as well as an in depth understanding of the issues associated with renewable energies and their development, including the short and medium-term technical, technological, geopolitical and environmental challenges.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics, Mathematics I and II, Basic Electrical And Electronics Engineering,

Course objectives:

1. To accustom about introduction to energy engineering, energy resources and forms of energy.
2. To learn conventional energy sources like coal and types of coal and byproduct, Petroleum, Natural gas and Refinery Products.
3. To understand solar energy, wind energy, geothermal, tidal energy, Bio energy.
4. To learn the Chemical Energy Sources- Fuel cell, Hydrogen, Methanol, Nuclear energy.
5. To understand national energy strategies and national energy plants and energy audit of company.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply knowledge of mathematics, science, and engineering to various energies.
2. Analyze and interpret the data i.e. the conventional and nonconventional source of energy, national energy strategy and energy plans, energy power management, energy audit, various energy conversion processes, devices and the power plants.
3. Understand conventional energy sources like Coal and types of coal and byproduct, Petroleum, Natural gas and Refinery Products.
4. Demonstrate Fuel cells and design and operation of a Fuel cell.
5. Analyze Nuclear Energy, Solar Energy and Wind Energy.

COURSE CONTENT

Energy Engineering		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Energy engineering and energy technology: Law of conservation of Energy, Generalized equation of Energy conservation, Energy resources and forms of energy, Energy demand,

Changing energy consumption trends, National energy strategies of India, Crucial Issue in India's energy planning. Energy power management and Energy planning in India. Energy Audit- Types of Energy Audits Conservation and recycling.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Conventional Energy Sources

Coal: Type of coal, classification of Indian coal. Important Properties of coal. Exploration, Coal Preparation, Removal of sulphur, Storage and Transportation of coal. Coal gasification, coal liquefaction.

Petroleum, Natural gas and Refinery Products: Introduction to Petroleum and Natural gas and Naphtha. Exploration of petroleum. Production of crude oil and Natural gas. Transportation of crude oil and Natural gas. Refining of crude oil and Natural gas Refinery. Liquefaction of Natural gas

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Chemical Energy Sources:

Fuel cells: Introduction, Design and operation of a Fuel cell. Classification of fuel cells: Types of fuel cells, Advantages and disadvantages of fuel cells, Applications of fuel cells. Hydrogen: Introduction, Applications of Hydrogen, Production of Hydrogen, Storage and transportation safety and management, Hydrogen technology development in India.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Nuclear Energy: Nuclear energy and application compared with coal, Fuels for Nuclear Fission Reactor. Storage and Transportation. Energy from Nuclear fission reactor. Fast breeder Reactor. Boiling water reactor. Pressurized heavy and Light Water reactor. Uranium Enrichment Process. Nuclear Waste Management.

Solar Energy: Terms and definition, units. Application of solar heater solar energy storage, Thermal storage, battery storage. Applications of Solar energy. Wind energy: Basic Principles of wind energy conversion. Site Selection Considerations. Classification of wind energy conversion system, Wind power density, Power in wind stream, Forces on the blades of a propeller, Energy pattern factor, Definition of wind speed for Turbines.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Bio energy: Biomass energy resources, Biomass conversion processes, direct combustion of biomass, Thermo chemical conversion of biomass, Biochemical conversion, Ethanol from biomass, Applications, Biodiesel.

Energy conversion technologies and Electrical power plants: Power plants with conventional energy sources, Coal fired steam thermal power plants, Combined cycle power plants, Integrated coal gasification combined cycle power plants, Plant factors and reserves.

Text Book:

S. Rao and Dr. B.B. Parulekar, "Energy Technology" Non Conventional, Renewable and Conventional, Khanna Publishers, New Delhi.

Reference Books:

1. S.B. Pandya, "Conventional Energy Technology" Fuels and Chemical Energy Tata McGraw-Hill Publishing Company Ltd, New Delhi
2. S.P. Sukhatme, "Solar Energy", Principals of thermal collection and Storage. Tata McGraw-Hill Publishing Company Ltd, New Delhi

3. Thipse, S. S. " Alternative fuels" Jaico Publishing House; First edition , 2010
4. G.D. Rai "Non conventional Energy Sources", Khanna Publishers, New Delhi

Open Elective Course – I

Environmental Engineering

COURSE OUTLINE

Course Title:	**Environmental Engineering**	**Short Title:**	**ENVE**	**Course Code:**	

Course description:

This course describes the introduction of water, sewage, air and noise pollution and methods of control like sedimentation, Coagulation and flocculation, Filtration, Water softening and Disinfection.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics, Mathematics I and II, Engineering Graphics, Basic Electrical And Electronics Engineering, Industrial Chemistry, Thermodynamics-I & II, Fluid Mechanics, Material and Energy Balance Computations.

Course objectives:

1. To understand importance of water pollution environmental sanitation.
2. To demonstrate skill about sedimentation, coagulation and flocculation.
3. To identify sewage characteristics and its treatment.
4. To use know how about air pollution and control measures.
5. To accustom about filtration, Water softening, disinfection and advanced treatment methods.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the importance of water pollution environmental sanitation.
2. Apply the sedimentation coagulation and flocculation methodology.
3. Exhibit know how of sewage characteristics and its treatment and provide control measures for air pollution.
4. An ability to demonstrate the understanding of professional and ethical responsibilities about filtration and water softening methodology and advanced treatment methods for disinfection.
5. An ability to understand the environmental issues and to provide solutions for green and clean technologies.

COURSE CONTENT

Environmental Engineering		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Definition of environment and pollution, Elements of air pollution, Sources of air pollution, Permissible limits of air pollutants, Energy – environment – economics relationship, Effects

of air pollution on human beings, animals, plants and property, Global air pollution phenomena.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Water-Man's environment: Quality of water: Wholesomeness and palatability; physical, chemical, bacteriological standards. Treatment of water; impurities in water-processes for their removal – typical flow-sheets.
Sedimentation: factors affecting efficiency, design values of various parameters, tube settlers. Coagulation and flocculation: mechanisms, common coagulants, rapid mixing and flocculating devices.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Filtration: classification, slow and rapid sand filters, dual media filters, sand, gravel and under-drainage system, mode of action, cleaning, limitations, operational difficulties, performance, basic design consideration, pressure filters: construction and operation.
Water softening: lime soda and Base Exchange methods, principle reactions, design considerations, sludge disposal. Miscellaneous treatments: removal of iron and manganese, taste, odor and color, principles and methods; de-fluoridation.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Disinfection: Methods of disinfection, requirement of a good disinfectant, chlorination, chemistry of chlorination, kinetics of disinfection, chlorine demand, free and combined chlorine, break point chlorination, super chlorination, dechlorination, chlorine residual, use of iodine, ozone, ultraviolet rays and chlorine dioxide as disinfectants, well water disinfection.
Introduction to advanced treatment methods: reverse osmosis, electro – dialysis, floatation, micro filtration, ultra filtration, Nano filtration.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Importance of environmental sanitation, Waste water sources, Mechanism of water pollution, Importance of dissolved oxygen, Classification of microorganisms, Aerobic and anaerobic cycles of decomposition, Role of enzymes, Concept of biodegradability, Factors affecting biodegradability, B.O.D., Kinetics of microbial growth in a batch reactor, reduction of B.O.D. with time, Nitrification concept, Mathematical modeling of B.O.D. removal, Oxygen sag curve (No mathematical treatment), Introduction to conventional waste water treatment scheme.

Text Books:

1. B.C.Punmia and A. K. Jain and A.K.Jain, Waste Water Engineering, Firewall Media Publication.
2. M.N.Rao, H.N.Rao, Air Pollution, Tata McGraw Hill Publication.

Reference Books:

1. S.K.Hussain, Textbook of Water Supply and Sanitary Engineering, Publisher: Oxford & IBH Publishing Co Pvt. Ltd.
2. Warren Viseman Jr., Mark J Hammer, Elizabeth M Perez, Paul A Chadk, Water Supply and Pollution Control, Pearson New International Publisher.

Open Elective Course – I					
Biochemical Engineering					
COURSE OUTLINE					
Course Title:	**Biochemical Engineering**	**Short Title:**	**BCE**	**Course Code:**	

Course description:

The course consists of study of Biological Material & Energy Balances for bioprocesses & unit operations used in the bioprocesses. It also includes Enzyme Engineering. Immobilization of enzymes and kinetic study of the enzyme catalyzed reactions. Study of microbial kinetics, various models, different types of Bioreactors with material balances are the integral part of this course. Sterilization reactors, air sterilization, O_2 transport in bioprocesses, recovery of the fermentation products followed by instrumentation and control are also included in the course.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Thermodynamics-I and II, Fluid Mechanics, Material and Energy Balance Computations.

Course objectives:

1. To know about the biological materials to obtain various chemicals from them and Energy and Material balances for the bioprocesses and Unit operations involved in these processes.
2. To learn Enzyme Engineering.
3. To accustom with kinetics of microbial growth, various models and different reactor configurations for the growth of microorganisms.
4. To understand sterilization of liquids and air, O_2 transport through cell and determination of oxygen transfer coefficients.
5. To introduce the unit operations for the recovery of fermentation products and the application of controls and instrumentations in bioprocesses.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply a knowledge and understanding of various biochemical processes for the recovery of many important chemicals and biochemical's.
2. Utilize the principles of hygiene.
3. Demonstrate the understanding of basic science and engineering.
4. Use the knowledge of chemical engineering to design efficient product bioprocesses by designing bioreactors and effective downstream processing mechanism.
5. Understand the environmental issues and to provide solutions for green and clean technologies.

COURSE CONTENT

Biochemical Engineering		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams	**40**

	(ISE):	**marks**
Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Characteristics of Biological material. Types of microorganisms; general physical properties of cells and chemical composition of cells; requirement for growth of cells and formulation of media; reproduction cycles in microorganisms; changes in composition of cells with age and with growth rate; effect of substrate limiting growth on the composition of cells; strain breeding; Maintenance of pure cultures.
Material Balances in bioprocesses, Application of material balances to bioprocesses.
Energy balances in bioprocesses, Heat of reaction for processes with biomass production. Unsteady state energy and material balances in bioprocesses.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Enzymes. History. Enzyme nomenclature and classification. Applications of enzymes. Enzyme substrate complex and enzyme action. Effect of Temperature and pH on enzyme activity. Kinetics of enzyme catalyzed reaction; simple enzyme kinetics with one and two substrates; Michaelis Menten kinetics. Evaluation of parameters of Michaelis Menten equation. Kinetics of reversible enzyme catalyzed reaction. Enzyme inhibition. Types of enzyme inhibition. Kinetics of competitive, uncompetitive and noncompetitive enzyme inhibition. Substrate activation and inhibition. Immobilization of enzymes and their applications.

Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**

Microbial Kinetics: Monod's growth kinetics. Environmental effects on growth kinetics. Balanced growth kinetics, Transient growth kinetics, Unstructured batch growth model, Growth of filamentous organisms, Product formation kinetics. Unstructured model.
Reactor Configurations: Batch growth of microorganisms, Stirred tank reactor with recycle of biomass, Continuous stirred tank fermenters in series, plug flow fermenter, fed batch fermenter, Numericals on these, multiphase reactors such as packed bed reactors, bubble column reactors, fluidized bed reactors and trickle bed reactors.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Sterilization: Importance of Sterilization. Batch Sterilization of liquids, continuous sterilization of liquids, and sterilization of air.
Aeration and Agitation: Mass transfer and Microbial respiration, bubble aeration and mechanical agitation, correlation between oxygen transfer coefficient and operating variables, effect of temperature, organic substances, surface active agents, mycelium and types of sparger on oxygen transfer coefficient. Measurement of oxygen transfer coefficient, Scale up.

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Recovery of fermentation products, Disruption of cells, mechanical methods, ultrasonic vibrations, grinding and mechanical shear, shearing by pressure, induction by lysis.
Reverse Osmosis: Ultra filtration, Instrumentation and Control: Introduction, methods of measuring process variables; temperature measurement and control, pressure measurement and control, foam sensing and control, weight of fermenter and estimation of microbial biomass, dissolved oxygen measurement and control, inlet and exit gas analysis, pH measurement and control, bioprocess economics.

Text Books:

1. James E. Bailey & David F. Ollis, Biochemical Engineering. Fundamentals; McGraw Hill

Publication.
2. Doran Pauline M. Bioprocess Engineering Principles, Academic Press. An Imprint of Elsevier.4. Shular Michael L. and Kargi Fikret. Bioprocess Engineering Basic Concepts, Prentice Hall of India.

Reference Books:

1. Shuichi Aiba, Arthur E3.H. & Nancy F.M., Biochemical Engineering; University of Tokyo Press.
2. P.F.Stanbury, A. Whitaker & S,J.Hall, Principles of Fermentation Technology; Aditya Books Ltd; New Delhi.
3. Shular Michael and Kargi Fikret, Bioprocess Engineering Basic Concepts, Prentice Hall of India
4. Editors: J.F. Richardson, D.G. Peacock, Coulson's & Richardson's Chemical Engineering, (Vol-III) Asian Books Pvt. Ltd. New Delhi
5. J.H. Backhurst & J.H.Harker, Coulson's & Richardson's Chemical Engineering (Vol-V) Asian Books Pvt. Ltd.

Open Elective Course – I

Thermal Engineering

COURSE OUTLINE

Course Title:	**Thermal Engineering**	**Short Title:**	**TE**	**Course Code:**	

Course description:

This course is designed for the students to study advanced level- concepts of thermal engineering, and to explore new areas in thermal energy systems and allied sciences.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics, Thermodynamics-I, Thermodynamics-II, Basic Electrical And Electronics Engineering and Material Science.

Course objectives:

1. To prepare students to excel in Thermal engineering profession.
2. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve thermal engineering problems.
3. To train the students with good scientific and engineering knowledge so as to comprehend, analyze, design and create novel products and solutions for the real life problems.
4. To inculcate professional and ethical attitude, teamwork skills in the students.
5. To prepare students for multidisciplinary approach to solve thermal engineering related issues.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the comprehensive knowledge about the kinetic theory of gases.
2. Learn the different types of fuels & their working adaptability.
3. Apply thermodynamic principles in real gas behavior, availability analysis, statistical and irreversible thermodynamics.
4. Demonstrate the ability for solving energy related contemporary issues.
5. Apply the principles of thermodynamics in thermal engineering for solving real world problems.

COURSE CONTENT

Thermal Engineering		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Kinetic theory of gases:

Gas Laws, Kinetic gas equation, Equation of state for a perfect gas, P-V-T surface of an Ideal gas, Internal Energy & Enthalpy of a Perfect gas, Specific heat capacities of an ideal gas, Real gases, Vander Waal's equation, compressibility chart, molecular velocities, probability

distribution of velocities, mean free path, collision diameter, collision number, Dalton's law, diffusion, Graham's law of diffusion.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Properties of pure substances:
Pure substance, phase change of pure substance, pressure-temperature diagram for a pure substance, phase change terminology & definitions, terms related to steam formation, formation of steam & its graphical representation, thermodynamic properties of steam & steam tables, Mollier diagram, determination of dryness fraction of steam.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Fuels & combustion:
Fuels, classification of fuels, combustion equations, theoretical air & excess air, stoichiometric air: fuel (A/F) ratio, analysis of exhaust gas & flue gas, calorific value of fuels, determination of calorific value of solid, liquid & gaseous fuel, adiabatic flame temperature, combustion analysis.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Internal combustion engines I:
Heat engines, development, classification, applications of I.C. engines, different parts of I.C. engines: parts common to petrol & diesel engine, only for petrol engines, only for diesel engines. I.C. engine terms, working cycles.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Internal combustion engines II:
Comparison of S.I & C.I engines, comparison between petrol &diesel engine, Ignition system (Petrol engines), fuel injection system (Diesel engines), electronic fuel injection, cooling systems, lubrication systems, governing of I.C. engines, performance of I.C. engines.

Text Books:

1. R.K.Rajput, Thermal Engineering (Eight edition), Laxmi Publications Pvt.Ltd.,New Delhi.
2. Domkundwar, Kothandaraman, Domkundwar, A Course in Thermal Engineering (sixth revised & enlarged edition), Dhanpat Rai & Compony Pvt.Ltd., New Delhi

Reference Books:

1. P.L. Ballaney, Thermal Engineering (In S.I.units) (24th edition), Khanna Publishers, New Delhi.
2. Maron-Prutton, Principles of Physical chemistry: Oxford & IBH publishing Co.Pvt.Ltd. New Delhi

Mass Transfer-I Lab					
LAB COURSE OUTLINE					
Course Title:	**Mass Transfer-I Lab**	**Short Title:**	**MT-I Lab**	**Course Code:**	

Course description:

This course describes how practically Mass Transfer takes place within and during inter-phase transfers. It aims to understand, operate various equipments and gain practical knowledge of diffusion phenomenon through experimentation.

Laboratory	Hours/week	No. of weeks	Total hours	Semester credits
	2	14	28	1

End Semester Exam (ESE) Pattern:	Practical (PR)

Prerequisite course(s):

Chemistry Lab, Physics Lab, Material and Energy Balance Computations Lab, Chemical Engineering Lab-II

Course objectives:

1. To reinforce concepts of Mass Transfer operation through experimentation.
2. To accustom of unit operations like absorption, humidification, crystallization, drying operation etc.
3. To analyze & interpret data obtained during performance of the experiment for understanding the Mass Transfer lecture course.
4. To improve technical skills & ability by formulating a solution through experimentation.
5. To demonstrate the understanding of professional and ethical responsibilities

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Recognize types of diffusion and the mechanism of diffusion.
2. Demonstrate an ability to solve the mass transfer problems by calculating the Mass Transfer Coefficient.
3. Use practical considerations for designing and operation of mass transfer operations / equipments.
4. Identify, formulate, design and provide the solution to various chemical engineering problems.
5. Understand the environmental issues and to provide solutions for green and clean technologies.

LAB COURSE CONTENT

Mass Transfer-I Lab		Semester:	V
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**End semester exam (ESE):**	**25 marks**
		Internal Continuous Assessment (ICA):	**25 marks**

(Amongst the following any eight experiments / assignments are to be performed)

1. Diffusion in Still Air: To estimate mass transfer coefficient for given system at room temperature.

2. Liquid – Liquid Diffusion: To determine diffusion coefficient for given system as function of concentration.
3. Solid – Liquid Diffusion: To determine mass transfer coefficient for dissolution of given system without chemical reaction.
4. Solid in Air Diffusion: To calculate mass transfer coefficient for vaporization of given solid in air using packed bed.
5. Wetted Wall Column: To determine mass transfer coefficient for air – water system.
6. Cooling Tower: To determine volumetric mass transfer coefficient for air – water system.
7. Absorption in Packed Column: To find mass transfer coefficient of given system.
8. Crystallization: To determine percentage yield of crystallization without and with seeding.
9. Natural Drying: To obtain drying curve for batch drying operation.
10. Fluidized Bed Dryer: To determine the rate of drying and to obtain mass transfer coefficient for the given material.

Text Book:

Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers.

Reference Books:

1. Coulson & Richardson Chemical Engineering (Vol. I), Butterworth-Heinmann (Elsevier) (Sixth Edition).
2. Coulson & Richardson Chemical Engineering (Vol. II), Butterworth-Heinmann (Elsevier) (Fifth Edition).
3. R.E.Treybal, Mass transfer operation, McGraw Hill Book Company, (Third Edition).

Guide lines for ICA:

Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal

Guidelines for ESE: End Semester Examination shall be based on practical / oral evaluation of Student performance and practical / assignments submitted by the student in the form of journal.

Chemical Reaction Engineering- I Lab					
LAB COURSE OUTLINE					
Course Title:	**Chemical Reaction Engineering-I Lab**	**Short Title:**	**CRE-I Lab**	**Course Code:**	

Course description: The intent of this course is to help to understand concepts in chemical reaction engineering. This course describes experimental techniques for determining rate laws for chemical reactions, the mechanisms and theories of chemical reactions.

Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	2	14	28	1

End Semester Exam (ESE) Pattern:	**Oral (OR)**

Prerequisite course(s):

Chemistry Lab, Physics Lab, Material and Energy Balance Computations Lab and Chemical Engineering Lab-II.

Course objectives:

1. To accustom with homogenous reactions.
2. To introduce and learn the multiple reactions and concept of residence time distribution.
3. To understand various Models for non-ideal flow, concept of micro and macro mixing.
4. To evacuate the ideal batch reactor, mixed flow reactor, plug flow reactor.
5. To analyze & interpret data obtained during performance of the experiment.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Demonstrate the concepts of chemical reaction engineering using knowledge of basic Sciences and Mathematics.
2. Accustom of reactors, residence time distribution and concept of micro and macro mixing.
3. Identify, formulate, design and provide the solution to various reactors such as Continuous Stirred Tank Reactor, Plug Flow Reactor, and Packed Bed Reactor by obtaining experimental data.
4. Demonstrate the understanding of professional and ethical responsibilities.
5. Understand the environmental issues and to provide solutions for green and clean technologies.

LAB COURSE CONTENT

Chemical Reaction Engineering-I Lab		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**End semester exam (ESE):**	**25 marks**
		Internal Continuous Assessment (ICA):	**25 marks**

(Amongst the following any eight experiments / assignments are to be performed)

1. To determine the reaction rate constant {k} for given reaction.(CSTR / BATCH / SEMIBATCH / PFR)
2. To determine the effect of temperature on reaction rate constant. .(CSTR / BATCH / SEMIBATCH / PFR)
3. To determine the activation energy {E} for the given reaction. .(CSTR / BATCH / SEMIBATCH / PFR)
4. To draw C [t], E [t] & F [t] curve and to calculate the mean residence time {tm} variance

5. $\{\sigma^2\}$ and skew ness $\{S^3\}$ for plug flow reactor.
6. To draw C [t], E [t] and F [t] curve and to calculate the mean residence time {tm} variance $\{\sigma^2\}$ and skew ness $\{S^3\}$ for packed Bed reactor.
7. To study the cascaded CSTR
8. To draw C [t], E [t] and F [t] curve and to calculate the mean residence time {tm} variance $\{\sigma^2\}$ and skew ness $\{S^3\}$ for Annular reactor.
9. To study the kinetic in tubular flow reactor [coiled tube] for the given reaction.

Text Books:

1. Octave Levenspiel, Chemical Reaction Engineering, John Wiley and Sons.
2. Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers.

Reference Book:

H.Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall New Jersey.

Guide lines for ICA:

Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal.

Guidelines for ESE: End Semester Examination shall be based on practical / oral evaluation of Student performance and practical / assignments submitted by the student in the form of journal.

Chemical Engineering Lab-III					
LAB COURSE OUTLINE					
Course Title:	**Chemical Engineering Lab-III**	**Short Title:**	**CEL – III**	**Course Code:**	

Course description:

This course intended to fulfill the need for comprehensive laboratory course in Particle and Fluid-Particle Processing.

Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	2	14	28	1

End Semester Exam (ESE) Pattern:	**Oral (OR)**

Prerequisite course(s):

Chemistry Lab, Physics Lab, Material and Energy Balance Computations Lab, Chemical Engineering Lab-II.

Course objectives:

1. To understand and apply engineering experimentation techniques and safety procedures common to the chemical industry.
2. To apply principles developed in chemical engineering courses to the analysis of chemical engineering processes and unit operations.
3. To improve technical skills size reduction and screening during process.
4. To study various Laws of crushing, Energy utilization, crushing Efficiency, Energy for size reduction.
5. To give the knowledge of various equipment for classification of particulate matter

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Understand the size of the product according to utilization into proper size reduction equipment.
2. Visualize, formulates, analyze and solve basic engineering problem of equipments.
3. Accustom with scientific principles and apply them to the practice of engineering problems.
4. Understand and predict the applications of filtration processes and its working and carrying out the design of engineering layout.
5. Design and fabricate screw conveyor, chain and flight.

LAB COURSE CONTENT

Chemical Engineering Lab-I		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**End semester exam (ESE):**	**25 marks**
		Internal Continuous Assessment (ICA):	**25 marks**

(Amongst the following any eight experiments / assignments are to be performed)

1. To study the separation of solids by sedimentation.
2. To study the differential and cumulative screen analysis of sand.(Sieve analysis)
3. To verify the laws of crushing and grinding by ball mill
4. To verify the laws of crushing and grinding by Jaw crusher
5. To determine the rate of filtration, cake resistance and filter medium resistance.

6. To determine the rate of filtration by vacuum filter.
7. To study the behavior of the bed during fluidization and to calculate minimum fluidization velocity.
8. To study the sigma Kneader Mixer.
9. To study the operating behavior of cyclone separator and to find out its efficiency.
10. To study the Ribbon Blender and to find out the mixing index.

Text Books:

1. Mc Cabe W. L. & Smith J. C. "Unit Operation for Chemical Engg." fifth edition, McGraw Hill Kogakusha Ltd.
2. R.S.Hiremath and A.P.Kulkarni, Unit Operation of Chemical Engineering. Everest publishing House.
3. Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers

Reference Books:

1. Badger W. L. & Banchero J. T. “Introduction to Chemical Engg." McGraw Hill International Book Co. New Delhi.
2. P. Chattopadhaya “Unit Operation In Chemical Engg. Vol. I "Khanna Publication Delhi.

Guide lines for ICA:

Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal.

Guidelines for ESE:

End Semester Examination shall be based on practical / oral evaluation of Student performance and practical / assignments submitted by the student in the form of journal.

Minor Project (Stage – I)					
LAB COURSE OUTLINE					
Course Title:	**Minor Project (Stage – I)**	**Short Title:**	**MPROJ-SI**	**Course Code:**	

Course description:

Minor project represent the culmination of study towards the Bachelor of Engineering degree. The minor project offers the opportunity to apply and extend material learned throughout the program. The emphasis is necessarily on facilitating student learning in technical, project management and presentation spheres.

Laboratory	Hours/week	No. of weeks	Total hours	Semester credits
	6	14	84	3

End Semester Exam (ESE) Pattern:	----

Prerequisite course(s):

-

Course objectives:

1. To understand the basic concepts & broad principles of projects.
2. To understand the value of achieving perfection in project implementation & completion.
3. To apply the theoretical concepts to solve problems with teamwork and multidisciplinary approach.
4. To demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context.
5. To develop ability of extracting the material from the different sources and writing comprehensively and exhaustive report on an allotted topic.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Demonstrate a sound technical knowledge of their selected project topic.
2. Undertake problem identification, formulation and solution.
3. Design engineering solutions to complex problems utilizing a systems approach.
4. Conduct an engineering project
5. Demonstrate the knowledge, skills and attitudes of a professional engineer.

LAB COURSE CONTENT

Minor Project (Stage – I)		Semester:	V
Teaching Scheme:		**Examination scheme:**	
Practical:	**6 hours/week**	**Internal Continuous Assessment (ICA):**	**50 marks**

At third year the students shall carry out a minor project in a group of maximum up to 5 students. The project work spans both the semesters. By the end of Semester – V the students

shall complete the partial work, and by the end of Semester – VI the students shall complete remaining part of the project. Assessment for the project shall also include presentation by the students. Each teacher can guide maximum 04groupsofminor projects.

The students should take project work, as specified in the curriculum, based on the knowledge acquired by the students during the degree course till Semester – IV. The project may be either fully theoretical / practical or involving both theoretical and practical work to be assigned by the Department. The work may also be Study / Survey / Design.

Minor Project (Stage – I) may involve literature survey, problem identification, design methodology, collection of data etc. The project work shall involve sufficient work so that students get acquainted with different aspects of design and analysis. Approximately more than 50% work should be completed by the end of Semester – V. Each student group should submit partial project report in the form of thermal bound at the end of Semester –V.

Each student group is required to maintain separate log book for documenting various activities of the project.

Suggestive outline for the partial project report is as follows.

Abstract

Chapter 1. Introduction

Chapter 2. Literature Survey

Chapter 3. Methodology

Chapter 4. Results & Discussion

Chapter 5. Conclusion

Bibliography

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Appendix

Guide lines for ICA:

The Internal Continuous Assessment (ICA) for project shall be based on continuous evaluation of students' performance, active participation, knowledge / skill acquired throughout semester and presentation by the students. The assessment shall be done jointly by the guide and departmental committee. A three-member departmental committee including guide, appointed by Head of the department, shall be constituted for the assessment. The assessment for Minor Project (stage – I) in Semester – V shall be as per the guidelines given in Table – A.

Table – A

		Assessment by Guide					Assessment by Departmental Committee		
Sr. No.	Name of the Student	Attendance / Participation	Problem Identification / Project Objectives	Literature Survey	Methodology / Design	Report	Depth of Understanding	Presentation	Total
	Marks	5	5	5	5	5	10	15	50

Constitution of India

Basic features and fundamental principles

The Constitution of India is the supreme law of India. Parliament of India cannot make any law which violates the Fundamental Rights enumerated under the Part III of the Constitution. The Parliament of India has been empowered to amend the Constitution under Article 368, however, it cannot use this power to change the "basic structure" of the constitution, which has been ruled and explained by the Supreme Court of India in its historical judgments. The Constitution of India reflects the idea of "Constitutionalism" – a modern and progressive concept historically developed by the thinkers of "liberalism" – an ideology which has been recognized as one of the most popular political ideology and result of historical struggles against arbitrary use of sovereign power by state. The historic revolutions in France, England, America and particularly European Renaissance and Reformation movement have resulted into progressive legal reforms in the form of "constitutionalism" in many countries. The Constitution of India was made by borrowing models and principles from many countries including United Kingdom and America.

The Constitution of India is not only a legal document but it also reflects social, political and economic perspectives of the Indian Society. It reflects India's legacy of "diversity". It has been said that Indian constitution reflects ideals of its freedom movement; however, few critics have argued that it does not truly incorporate our ancient legal heritage and cultural values. No law can be "static" and therefore the Constitution of India has also been amended more than one hundred times. These amendments reflect political, social and economic developments since the year 1950. The Indian judiciary and particularly the Supreme Court of India have played an historic role as the guardian of people. It has been protecting not only basic ideals of the Constitution but also strengthened the same through progressive interpretations of the text of the Constitution. The judicial activism of the Supreme Court of India and its historic contributions has been recognized throughout the world and it gradually made it "as one of the strongest court in the world".

Course content

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the fundamental rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy – Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India
9. Amendment of the Constitutional Powers and Procedure
10. The historical perspectives of the constitutional amendments in India
11. Emergency Provisions: National Emergency, President Rule, Financial Emergency
12. Local Self Government – Constitutional Scheme in India
13. Scheme of the Fundamental Right to Equality
14. Scheme of the Fundamental Right to certain Freedom under Article 19
15. Scope of the Right to Life and Personal Liberty under Article 21

KAVAYITRI BAHINABAI CHAUDHARI

NORTH MAHARASHTRA

UNIVERSITY, JALGAON (M.S.)

Third Year Engineering

(Chemical Engineering)

Faculty of Science and Technology

SYLLABUS

Semester - VI

W.E.F. 2020 – 21

Mass Transfer-II					
COURSE OUTLINE					
Course Title:	**Mass Transfer-II**	**Short Title:**	**MT-II**	**Course Code:**	

Course description:

The purpose of this course is to introduce the fundamental concepts, principles to various separation processes such as distillation, liquid- liquid extraction, solid liquid extraction, adsorption and ion exchange. The course illustrates new techniques of separation such as membrane separations and their possible areas of industrial application.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
Lecture	03	14	42	03

Prerequisite course(s):

Chemistry, Physics, Industrial Chemistry, Material and Energy Balance Computations, Fluid mechanics, Mass Transfer-I, Chemical Reaction Engineering-I.

Course objectives:

1. To learn the vapor liquid equilibrium and importance of relative volatility in distillation.
2. To understand different methods of distillation.
3. To apply various liquid-liquid extraction processes.
4. To understand adsorption and ion exchange operation.
5. To demonstrate knowledge of mass transfer in leaching operation.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply mass transfer principles to various phase equilibrium based separation processes viz. perform graphical calculations for binary distillation.
2. Understand and apply process design principles for large scale industrial separators – process design of liquid-liquid; solid liquid extraction.
3. Capable of identifying, formulating, designing and providing the solution to chemical engineering problems.
4. Develop the design of various equipments as per the standard specifications.
5. Demonstrate the caliber of mass transfer aspects in product design.

COURSE CONTENT

Mass Transfer-II		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to distillation process, Vapor liquid equilibrium, The methods of distillation (Binary mixture), - differential , flash, azeotropic, extractive, low pressure, steam distillation, batch rectification.

Condition for varying overflow in non- ideal system (Binary), Multi component mixture.

The fractionating column, Continuous rectification for binary system. Equipments for Distillation.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Multistage (Tray) towers: Bubble cap trays, Sieve trays, Valve trays. Tray efficiencies, concept of reflux, minimum reflux ratio, optimum reflux, total reflux. Lewis Sorrel, McCabe Thiele, and Ponchon Savarit methods for multistage operations.
Packed towers for distillation, Types of Packing's, NTU, HTU, HETP concept and calculations.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Introduction to extraction process, Liquid equilibria, Material balances for stage wise contact methods, Extraction with reflux, Fractional extraction, Stage contact and continuous contact type extractors.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Introduction to adsorption operation, Type of adsorption operation, Nature of adsorbents, Adsorption equilibria, Adsorption of vapor, gas mixture and liquids, Material balances for stage wise operation, Continues contact process for adsorption, Unsteady state fixed bed adsorption, Principle of ion exchange operation, Equilibria for ion exchange operation, Rate of ion exchange operation, Application of ion exchange operation.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Introduction to leaching operation, Mass Transfer in leaching operation, Calculation of stages for different processes, Graphical method for calculation of number of stages counter current washing process, Equipments for leaching operation.
Introduction to membrane separation process, Different Types of membrane separation process, (Ultrafiltration, Reverse Osmosis, Dialysis, Electro Dialysis, Pervaporation), General membrane equation, Liquid membrane.

Text Book:

Coulson & Richardson Chemical Engineering (Vol. II), Butterworth-Heinmann (Elsevier) (Fifth Edition).

Reference Books:

1. Christie J.Geankoplis, Transport Processes & Unit Operations, Prentice Hall Inc.
2. Coulson & Richardson Chemical Engineering (Vol.V), Butterworth-Heinmann (Elsevier).
3. R.E.Treybal , Mass transfer operation ,McGraw Hill Book Company, (Third Edition).

Chemical Reaction Engineering-II					
COURSE OUTLINE					
Course Title:	**Chemical Reaction Engineering-II**	**Short Title:**	**CRE-II**	**Course Code:**	

Course description:

This course describes to use appropriate terminology of chemical reaction engineering of heterogeneous nature and design. It illustrates basic scientific principles associated with the reactor design.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Chemistry, Industrial Chemistry, Thermodynamics-I & II, Fluid Mechanics, Material and Energy Balance Computations, Mass Transfer-I, Chemical Reaction Engineering-I, Particle and Fluid-Particle Processing.

Course objectives:

1. To learn the fluid particle reaction non-catalytic reactions and the determination of rate controlling step.
2. To understand the fluid-fluid system (without catalyst) and the reactors for gas-liquid reactions.
3. To accustom with the preparation and deactivation of catalyst and the determination of surface area and Pore volume of catalyst.
4. To apply knowhow about the solid catalyzed reactor and the diffusion and reaction in spherical catalyst pellets.
5. To design Moving Bed Reactor, Fluidized Bed Reactor, Slurry Bed Reactor, Trickle bed reactors, Isothermal and Adiabatic fixed bed reactor.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply basic kinetics and mass transfer principles for development of heterogeneous system rate expressions for fluid particle and fluid -fluid non catalytic reaction.
2. Demonstrate their ability how to prepare and use the catalyst for enhancements of reaction rate and understand its deactivation and generation.
3. Become competitive to undertake the designing of solid catalyzed reaction, Fluidized bed Reactors, Slurry bed reactors, Trickle bed reactors, Moving Bed Reactor, Isothermal and Adiabatic fixed bed reactor.
4. Display the research by designing, conducting, interpreting and analyzing experimental data for preparing reports.
5. Understand the environmental issues and to provide solutions for green and clean technologies.

COURSE CONTENT

Chemical Reaction Engineering-II		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams	**40 marks**

	(ISE):	
Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**
Introduction to fluid particle reaction non-catalytic reactions, unreacted core model for Spherical particle of unchanging size, Rate of reaction for shrinking spherical particles, Determination of rate controlling step , Various contacting patterns in fluid solid reactors for fluid particle non-catalytic reactions.		
Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Introduction to fluid-fluid system (without catalyst), Rate equation for Instantaneous, Fast, Intermediate and slow reaction, Slurry Reaction kinetics, Rate equation for infinitely slow reaction, Film conversion parameter , Reactors for gas-liquid reactions and their comparative evaluations on the basis of holdups. Aerobic fermentation, Tower for fast and slow reaction, Mixer settler and semi-batch contacting pattern. Reactive distillation and extractive reaction.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Introduction, Classification, Characteristics, Preparation and Deactivation of catalyst, promoters and inhibitors, Determination of surface area and Pore volume of catalyst, Adsorption process and its classification, Types of adsorption isotherm.		
Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**
Introduction to solid catalyzed reactor , Rate equation for adsorption , desorption and surface reaction, Diffusion and reaction in spherical catalyst pellets , Internal effectiveness factor, Overall effectiveness factor, Estimation of diffusion and reaction limited regimes, Mass transfer and reaction in a packed bed, The determination of limiting situation from reaction data, chemical vapor deposition reactors.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Introduction to heterogeneous catalytic reactors. Design, Mechanical construction and applications of: Moving bed reactors, Fluidized bed Reactors, Slurry bed reactors, Trickle bed reactors, Isothermal and Adiabatic fixed bed reactor.		

Text Books:

1. Octave Levenspiel, Chemical Reaction Engineering, John Wiley and Sons.
2. H.Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, New Jersey.

Reference Books:

1. J.M. Smith, Chemical Engineering Kinetics, McGraw Hill
2. Coulson & Richardson Chemical Engineering (Vol. III), Butterworth-Heinmann (Elsevier) (Sixth Edition).
3. Coulson & Richardson Chemical Engineering (Vol. V), Butterworth-Heinmann (Elsevier) (Sixth Edition).
4. S.D. Dawande, Principles of Reaction Engineering, Denett & Co., Nagpur
5. Lanny D. Schimdt , Chemical Reaction Engineering, Oxford University Press.
6. Froment and Bischoff, Chemical Reactor Analysis and Design, Wiley Publication, New York.
7. Hiroo Tominaga and Masakazu Tamaki, Chemical Reactions and Reactor Design, Wiley and Maruzene Publications.

Heat Transfer					
COURSE OUTLINE					
Course Title:	**Heat Transfer**	**Short Title:**	**HT**	**Course Code:**	

Course description:

This course aims to introduce students the heat transfer mechanisms in solids and fluids and their chemical process applications. The purpose of the course is to make student capable to model steady and unsteady heat transfer in simple systems, and design heat exchangers and simple heat exchanger networks.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics, Industrial Chemistry, Thermodynamics-I and II, Fluid Mechanics, Material and Energy Balance Computations, Mass Transfer-I

Course objectives:

1. To inculcate the heat transfer principles, various modes of heat transfer and t he individual & overall heat transfer coefficient and its significance.
2. To accustom with heat exchanger for conversion of hot and cold fluid and the design techniques involving heat transfer in chemical process.
3. To understand the dimensional analysis in heat transfer and the natural and forced convection.
4. To exhibit skill about the equation of one dimensional and three dimensional conduction.
5. To provide knowledge of the lumped heat capacity method of unsteady state conduction.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand conduction, convection and radiation modes applicable to design heat exchanging equipments widely used in chemical process and allied industry.
2. Apply the knowledge of individual and overall heat transfer coefficient for designing steady state and unsteady state heat transfer processes.
3. Provide suitable designing of heat exchanger and evaporator.
4. Demonstrate the understanding of professional and ethical responsibilities.
5. Understand the environmental issues and to provide solutions for green and clean technologies.

COURSE CONTENT

Heat Transfer		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Heat transfer by conduction in solids: Fourier's law of heat conduction, steady state heat conduction through walls (single and multilayer), heat flow through cylinder, unsteady state heat conduction. Derivation of Fourier's heat conduction equation for one dimensional conduction. Thermal insulation- insulating material, design factor and properties, optimum

thickness, critical thickness

Unit–II:	No. of Lectures: 09 Hours	Marks: 12

Heat transfer through extended surface of uniform cross section: Fin efficiency and its conditions, fin efficiency and effectiveness, counter current and parallel flows, energy balances, overall heat transfer coefficient , log mean temperature difference, individual heat transfer coefficient, calculation of overall heat transfer coefficient from individual coefficients , transfer units in heat exchangers.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Convection: Types of convection, empirical equations for forced convection, heat transfer in laminar and turbulent flow through tubes over a flat plate and submerged plate, dimensional analysis method, Dropwise and film type condensation, coefficient for film type condensation, Nusselt's equations, and application in petroleum industry.

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Heat transfer of boiling liquids: Boiling of saturated liquids, maximum flux and critical temperature drop, maximum Flux and film boiling.
Radiation heat transfer: Fundamental of radiation, black body radiation, laws of radiation, radiant heat exchange between non black surfaces. Greenhouse effect and radiation shape factor.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Heat exchange equipments:
Heat exchanger single pass 1-1 exchanger, 1-2 shell and tube heat exchanger, correction for LMTD for cross flow, design calculation (Kern Method) in heat exchanger.
Evaporation: Liquid characteristics and types of evaporator, single effect evaporator calculation, pattern of liquid flow in multiple effect evaporators.

Text Books:

1. Coulson & Richardson Chemical Engineering (Vol. I), Butterworth-Heinmann (Elsevier) (Sixth Edition).
2. Donald Q. Kern. Process Heat Transfer, Tata McGraw Publishing Company Limited, New Delhi (Tenth Edition).

Reference Books:

1. D.S.Kumar, Process Heat Transfer, S.K.Kataria and Sons Publisher, New Delhi.
2. W.L.McCabe and J.C.Smith, Unit Operations of Chemical Engineering, McGraw Hill/ International Edition (Seventh Edition).
3. S.S.Barkade and Mrs. P.L.V.N. Saichandra, Heat Transfer, Denett & Co., Nagpur.
4. D.C. Sikdar Process Heat Transfer and Chemical Equipment Design, Khanna Publishing House.
5. B.K. Dutta Heat Transfer: Principles and Applications, PHI.

Professional Elective Course – II					
Instrumentation and Instrumental Analysis					
COURSE OUTLINE					
Course Title:	**Instrumentation and Instrumental Analysis**	**Short Title:**	**IIA**	**Course Code:**	

Course description:

This course describes basic principles of instrumentation and instrumental analysis. The rationale of the course is to apply the principles learned in science and to provide characterization of solids and fluids for understanding the changes occurring in the chemical processes. This course aims to examine the variables and measure them to get exact product specifications.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics, Industrial Chemistry, Material Science.

Course objectives:

1. To learn the meaning and importance of measurement and elements of an instruments.
2. To accustom with static and dynamic characteristics of instruments.
3. To understand calibration of the instruments.
4. To understand basic principle behind measurements of an quantity by an instrument and their applicability in chemical processes.
5. To identify characterization of materials using modern instrumentation and techniques.

Course outcomes:

After successful completion of this course the student will be able to:

1. Learn basics of instrumentation, dynamic and static characteristics of an instrument.
2. Demonstrate the ability of measuring the quantities which are frequently involved in chemical process industries.
3. Identify the instrument needed for measuring the quantity in different working atmospheres.
4. Apply the knowledge for using modern tools and equipments in analytical research.
5. Apply the instrumentation principles for solving real world problems.

COURSE CONTENT

Instrumentation and Instrumental Analysis		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

Qualities of Measurement: The meaning of measurement, elements of instruments, Static Characteristics, Dynamic characteristic.

Expansion Thermometers: Introduction, Temperature scales, Constant volume gas

Thermometer, Bimetallic Thermometer, Industrial pressure spring Thermometer, Response of Thermometer.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Thermoelectric Temperature Measurement: Introduction, Simple thermocouple circuit, Industrial thermocouples, Thermocouple lead wires, thermal wells, response of thermocouples.
Resistance Thermometer: Introduction, Industrial resistance-thermometer bulbs, Resistance thermometer element, Resistance thermometer circuit, RTD.

Unit–III:	No. of Lectures: 09 Hours	Marks: 12

Radiation Temperature Measurement: Introduction, Black body conditions, Black body devices, Radiation receiving elements, Thermopile, Vacuum thermocouples, Radiation pyrometers , Lens type thermal radiation receiver , Photoelectric pyrometers, Photoelectric radiation receiver, Optical pyrometer.
Pressure and Vacuum Measurement: Introduction, Indicating pressure gage, Bellows pressure element, Useful ranges of absolute pressure measuring gages, McLeod vacuum gage.
Measurement of Pressure in Corrosion Fluids: The steam gage siphon, Diaphragm seal in Pressure measurement, Liquid seal in pressure measurement, Response of mechanical pressure gages.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Measurement of Level: Float and tape liquid level gage, Float & shaft liquid level unit, Level measurement in pressure vessels, Gamma ray method, Ultrasonic method & resistive method.
Introduction, Theory, Instrumentation, advantages, and Application of: pH measurement, Refractrometry, Potentiometry, colourometry, Flame photometry, and Conductometric titrations.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Introduction, Theory, Instrumentation, Advantages and Application of: Gas chromatography, Thin layer chromatography, Paper chromatography, HPLC.
Introduction, Theory, Instrumentation, Advantages and Application of: Infrared spectroscopy, Ultraviolet spectroscopy, Mass spectroscopy, NMR spectroscopy.

Text Books:

1. D.P.Eckman, Industrial Instrumentation, Willey Eastern Ltd., New Delhi.
2. Gurdeep Chatwal and Sham Anand, Instrumental methods of Chemical analysis, Himalaya Publication House, Mumbai.

Reference Books:

1. Nakra B.C. and K.K. Chaudhary, Instrumentation Measurement & Analysis, Tata – McGraw Hill, New Delhi.
2. Patranabis D. Industrial Instrumentation, Tata – McGraw Hill Publications, New Delhi.
3. V.P. Kudesia and S.S. Sawhaney, Instrumental methods of chemical analysis Pragati Prakashan, Meerut,U.P.
4. Dr.B.K.Sharma, Instrumentation methods of chemical analysis, Goel Publishing House, Meerut, U.P.

Professional Elective Course – II

Numerical Methods in Chemical Engineering

COURSE OUTLINE

Course Title:	**Numerical Methods in Chemical Engineering**	**Short Title:**	**NMC**	**Course Code:**	

Course description:

To introduce students to numerical methods used to solve engineering problems, in particular chemical engineering problems, using numerical methods and computer programming. Fundamentals of numerical methods/algorithms to solve systems of different mathematical equations (e.g. linear/ non-linear algebraic equations, ordinary /partial differential equations).

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Mathematics – I and II.

Course objectives:

1. To introduce basic methods, to solve mathematical problems and learn how to develop numerical methods and estimate numerical errors.
2. To choose the most appropriate numerical method for its solution based on characteristics of the problem and identify and classify the numerical problem to be solved.
3. Analyze the accuracy of the numerical solution and identify alternate strategies and methods to achieve greater accuracy when it is needed.
4. To develop an ability to identify chemical engineering problems.
5. Formulate a chemical engineering problem as a mathematical model, and select an appropriate solution method.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply knowledge of mathematics, science, and engineering to design.
2. Analyze and interpret data which is used for designing a system, component, or process to meet desired needs within economic constraints.
3. Exhibit their ability to identify, formulate, and solve engineering problems.
4. Exhibit knowledge of mathematical technique to solve industrial problems.
5. Demonstrate the ability of formulating and solving the LPP.

COURSE CONTENT

Numerical Methods in Chemical Engineering		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction, Approximation and concept of error and error analysis

Root Finding Methods: Bisection Method, Regula-falsi Method, Newton-Raphson Method,

Direct Integration Method, Muller's Method.
Solution Of Simultaneous Linear Equation: Gauss Elimination Method, Matrix Inversion Method, Gauss Jordan Method, Jacobi's Iteration Method, Gauss Seidal Method.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Interpolation & Extrapolation: Newtons-Gregory Forward Interpolation Formula, Newtons-Gregory Backward Interpolation Formula, Stirling's Formula, Central Difference Interpolation Formula, Choice of an Interpolation Formula.
Numerical Integration: Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule and Weddle's rule. integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical differentiation and integration

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Ordinary Differential Equations: Taylor's series method, Runge-Kutta method, Piccard's method, Eulers method and Least square method, Initial and boundary value problems, Chemical engineering problems involving single, and a system of ODEs.
Matrices: Matrix Algebra, Determinants of Square Matrices and Matrix Products the transpose of a matrix, adjoint matrices, reciprocal square matrix, rank and degeneracy of a matrix, submatrix, solution of linear algebraic equations, differentiation and integration of matrices.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Laplace Transform: Definition of Laplace Transform, Inverse Laplace transform, Properties and theorems, Laplace transforms of standard functions, Unit step functions, Ramp functions, Impulse functions, Error functions, Jump functions, Laplace Inverse Transform. Applications to the solutions of liquid systems, consisting of single tank & two tanks in series (Interacting & non-Interacting), Second order systems (Damped vibrator).

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Linear Programming (L.P.): Introduction to L.P., Formulation of L.P. Problems (L.P.P)/L.P. Models
Solution of L.P.P. by Analytical Method (containing two variables), Solution of L.P .P. By Graphical Method. Solution of L.P.P. with application of simplex technique.
Chemical engineering problems involving L.P.P.

Text Books:

1. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.
2. B.S. Grewal Numerical Methods In Engg. & Science, Khanna Publications; Delhi.
3. Jenson V.G., Jeffreys G.V., Mathematical Methods in Chemical Engineering, Elsevier Publications.

Reference Books:

1. S. Pushpavanam, Mathematical Methods in Chemical Engineering, PHI Learning Pvt. Ltd.
2. S.S. Sastry, Introduction To methods Of Numerical Analysis, Prentice Hall.
3. T.F. Edgar and B.M. Himellblau, Optimization of Chemical Processes, International Edition. McGraw Hill, 1989.
4. P.K. Gupta and D.S. Hira, Operation research 1st edition reprint, S. Chand & Company NewDelhi.1997.

Professional Elective Course – II					
Oil Technology					
COURSE OUTLINE					
Course Title:	**Oil Technology**	**Short Title:**	**OIT**	**Course Code:**	

Course description:

The purpose of this course is to expose students to the oils and fats methods used in industries and research. This course prepares the student to take up such challenges in his profession and understand important principles and present economic principles and their applications in the field of Chemical Engineering and Technology

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics, Industrial Chemistry, Thermodynamics-I and II, Fluid Mechanics, Material and Energy Balance Computations, Mass Transfer-I, Chemical Reaction Engineering-I.

Course objectives:

1. To introduce concepts of importance of oils, fats and waxes and learn scales of production various oils and its plant capacity.
2. To accustom with presence of adulteration in other vegetable oils and factors affecting solvent extraction plant and VOR.
3. To apply methods of vegetable oil refining and the byproducts from refining.
4. To analyze various analysis of oils, soaps and detergents.
5. To estimate optimum time and utility for production and provide the safety during processes.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the various factors responsible for establishing a chemical industry such as SEP, VOR, Soap & detergent industries.
2. Capable of applying their process engineering knowledge by allocating resources to obtain maximum productivity.
3. Exhibit their ability to identify, formulate, and solve engineering problems during productions.
4. Designing the product to meet economical and societal requirements.
5. Demonstrate the understanding of professional and ethical responsibilities.

COURSE CONTENT

Oil Technology		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	No. of Lectures: 09 Hours	Marks: 12
What are oils, Fats and Waxes?, Fatty acid composition and classification of oil and fats, sources, types, nomenclature, structures ,Non-glycerides, constituents and their importance, toxic constituents and detoxification. Physical and Chemical characteristics of Groundnut oil, Cottonseed, sunflower, soybean oil, linseed oil, rice bran oil. Utilization of Fats and oil in soap and oleo chemical Industries.		
Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Chemical reactions of fats and fatty acids like dehydration, sulphation & sulphonation, esterification, interesterification, hydrolysis and hydrogenation, Isomerisation and polymerization, Nutritional significance of oils and fats. Waxes, Oxidation, Autoxidation, Rancidity, Antioxidants, etc.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Elementary analysis of oils ,fats and waxes, Physical and Chemical analysis of oils and fats, thiocyanogen value, acetyl and hydroxyl values, peroxide value, Reichert Meissel, Polenske and Kirschner values etc. Thin layer, column and Gas liquid chromatography; BIS. standards for oils and oil cakes, detection of adulteration in oils and fats.		
Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**
Manufacture of soaps and detergents. Liquid Detergents, Industrial applications of surfactants. Manufacture and analysis of butter, Margarine, Vanaspati and other fat blends, Analysis of soaps and detergents, BIS standards for soaps and detergents, Classification of surfactants, Raw materials for soaps and detergents.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Mechanical and solvent extractions of oils, Degumming, Refining, Bleaching, Deodorization of oil and fats, hydrogenation and Vanaspati, cooking and salad oils, Confectionary fats, Animal Fats, Oleo chemicals : Production and Separation of fatty acids, Glycerol –recovery and uses, Bio- diesel, Types of Varnish, Alkyd resins, etc.		

Text Books:

1. Bailey's A. E, Industrial oils and Fats, Edition 6, Vol. I, II and III, Edited by Feireidoom Shahidi (2005).
2. Break and Bhatia, Handbook of Industrial Oil and Fat Products, CBS Publishers and Distributors, New Delhi. Vol 1 to 4.

Reference Books:

1. Technical Hand book of oils, fats and waxes, Vols 2, published by, Cambridge university, Press.
2. Devidson , Synthetic Detergent and Analysis , Published by John Wiley.I.
3. NIIR BOARD, Hand book on Soaps, Detergents and acid Slurry, 2nd Edition , Publisher- Asia Pacific Business Press Inc., Delhi.
4. NIIR BOARD, Hand book on Herbal Products, 2 vols. Publisher- Asia Pacific Business Press Inc.,Delhi.
5. NIIR BOARD, Essential oil Hand book, Publisher- Asia Pacific Business Press Inc., Delhi.
6. Fryer Perecival Technical Hand book of oils, fats and waxes, Vols 2, published by, Cambridge University Press.

Professional Elective Course – II					
Interfacial Engineering					
COURSE OUTLINE					
Course Title:	**Interfacial Engineering**	**Short Title:**	**IE**	**Course Code:**	

Course description:

The purpose of this course is to understand the fundamental concepts and applications of colloid and interface science. It deals with the colloid chemistry and interfacial phenomena at both fluid-fluid and solid-fluid interfaces.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics, Industrial Chemistry , Thermodynamics-I and II, Fluid Mechanics, Material and Energy Balance Computations, Mass Transfer-I, Chemical Reaction Engineering-I

Course objectives:

1. To introduce basic concepts of colloids and interfaces, interfacial phenomena, capillary phenomena, solid fluid interfaces
2. To understand importance of micellization and their applications
3. To understand importance of microemulsions and their applications
4. To accustom with introduction of flocculation and their applications
5. To learn adsorption, film formation, flotation and types of flotation.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand concepts of colloids and interfaces.
2. Apply know how of micellization for their potential applications.
3. Understand microemulsions and their applications.
4. Apply various types of flocculation and flotation in terms of industrial requirement.
5. Identify adsorption, film formation and types of flotation.

COURSE CONTENT

Interfacial Engineering		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction; basic concepts of colloids and interfaces, interfacial phenomena, capillary phenomena, solid fluid interfaces, colloids ,properties of colloids, stability of colloids, preparation of colloids, colloidal dispersions parameters of colloidal dispersions

Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**

Micellization, The Critical Micelle Concentration (CMC), Micellar Structure and Shape,

Micellar Aggregation Numbers, Factors Affecting the Value of the CMC in Aqueous Media, Micellization in Aqueous Solution and Adsorption at the Aqueous Solution–Air or Aqueous Solution–Hydrocarbon Interface, CMCs in Nonaqueous Media		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Colloid interactions and flocculation, , theory of flocculation, types of flocculation, methods of flocculation, equipments for flocculation, polymeric flocculants, applications of flocculation		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Dispersions, rheology of dispersions; emulsification, types of emulsions, preparation of emulsion, stability of emulsions, phase inversions ,flocculation and coalescence of drops, application of emulsification		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Microemulsions, Winsor's classification of microemulsions, stability of microemulsions, , rheology of microemulsions, applications of microemulsions Adsorption and film formation; theory of flotation, types of flotation, equipments for flotation, application of flotation.		
Text Books:		
1. Pallab Ghosh, Colloid and Interface Science. 2. Milton J. Rosen Joy T. Kunjappu, Surfactants and Interfacial Phenomena, Fouth edition,Wiley Editing Services.		
Reference Books:		
1. Coulson & Richardson Chemical Engineering (Vol. II), Butterworth-Heinmann (Elsevier) (Fifth Edition). 2. Coulson & Richardson Chemical Engineering (Vol. III), Butterworth-Heinmann (Elsevier) (Third Edition)		

Open Elective Course – II					
Alternative Fuels					
COURSE OUTLINE					
Course Title:	**Alternative Fuels**	**Short Title:**	**AFS**	**Course Code:**	

Course description:

This course provides an introduction to alternative fuels like hydrogen, CNG, biodesel, producer gas, ammonia and liquid nitrogen and its production, storages, safety consideration keeping environmental norms.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics, Mathematics I and II, Energy Engineering

Course objectives:

1. To accustom concept of hydrogen as a freedom fuel, its production, on board storage, stationary storage, piping, dispensers, transportation, advantages and disadvantages, hazard, safety, standards and uses in IC and SI engine, CI engine.
2. To understand about CNG and its production, storage, advantage and disadvantages, dispensing system, transportation, fuel kits, engine modification for CNG operation, CNG combustion.
3. To learn the environmental and economics while using biodiesel and also learn about its production, storage, dispensing, biodiesel standards, biodiesel transportation, advantages and disadvantages.
4. To identify composition and properties of producer gas use know how for production of producer gas.
5. To understand use of ammonia as an automotive fuel keeping environmental norms, a carrier for hydrogen, a fuel cell vehicles and for locomotives and also liquid nitrogen as a fuel.

Course outcomes:

After successful completion of this course the student will be able to:

1. Display the skill of know of hydrogen, its production, on board storage, stationary storage, piping, dispensers, transportation, advantages and disadvantages, hazard, safety, standards and uses in IC and SI engine, CI engine.
2. Analyze the CNG production and its, storage, advantage and disadvantages, dispensing system, transportation, fuel kits, engine modification for CNG operation, CNG combustion.
3. Exhibit skills eco friendly use of biodiesel and its production, storage, dispensing, biodiesel standards, biodiesel transportation, advantages and disadvantages.
4. Apply means of maintaining productivity by identify composition and properties of producer gas.
5. Demonstrate the ability for providing solutions for use of ammonia and liquid nitrogen as a fuel.

COURSE CONTENT

Alternative Fuels		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60**

			marks
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Hydrogen: The freedom fuel

Introduction, history of hydrogen, properties of hydrogen, production of hydrogen, on board storage of hydrogen, material compatibility for hydrogen, stationary storage for hydrogen, piping for hydrogen, dispensers for hydrogen, transportation of hydrogen, advantages and disadvantages of hydrogen, hazard of hydrogen, safety system for hydrogen, standards for hydrogen, hydrogen use in IC and SI engine, hydrogen used in CI engine, hydrogen combustion, emission from hydrogen, blend of hydrogen with CNG (Hythane / HCNG), hydrogen for fuel cells, review of hydrogen vehicle worldwide, hydrogen economy, hydrogen in India.

Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**

Compressed Natural Gas (CNG)

Introduction, history of CNG, production of CNG, properties of CNG, CNG storage, piping for CNG, advantage and disadvantages of CNG, CNG dispensing system, CNG transportation, material compatibility for CNG, CNG fuel kits, engine modification for CNG operation, CNG combustion, stoichiometric Vs lean burn CNG engines, CNG engines optimization, vehicle emission from CNG, aftertreatment of CNG exhaust, CNG fuelling station safety system CNG, standards and regulations, third party inspection for alternative fuels vehicles, CNG vehicle worldwide, CNG scenario in India

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Biodiesel

Introduction, history of biodiesel, biodiesel feedstock selection, raw materials for biodiesel production, biodiesel production, properties of biodiesel, biodiesel storage, biodiesel dispensing, biodiesel material compatibility, biodiesel standards, biodiesel transportation, advantages and disadvantages of biodiesel, hazards of biodiesel, second generation biodiesel, engine modification for biodiesel, biodiesel emission, biodiesel combustion, biodiesel vehicles, biodiesel senior in India

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Producer gas or Wood gas

Introduction, history of producer gas, composition of producer gas, properties of producer gas, production of producer gas, theory of gasification, advantages of producer gas, hazards of producer gas, application of producer gas, emission from producer gas, producer gas engine, producer gas vehicle, producer gas in India

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Ammonia

Introduction, history of ammonia as a fuel, properties of ammonia, ammonia in nature, health hazards of ammonia, ammonia as an automotive fuel, ZAP ammonia car, ammonia as a carrier for hydrogen, ammonia for stationary engine applications, ammonia on-board storage, ammonia for fuel cell vehicles, ammonia fuel cells for locomotives

Liquid nitrogen

Introduction, history of LN2 to as a fuel,: the Boese engine, LN2 car at the University of

North Texas, LN2 car at the University of Washington(UW), thermodynamic analysis of LN2 car at UW, liquid nitrogen economy

Text Books:

S.S.Thipse, Alternative Fuels, Jaico Publishing House, Mumbai

Reference Books:

1. Anthony San Pietro, "Biochemical and Photosynthetic aspects of Energy Production", Academic Press, 1980.
2. Bent Sorensen , "Renewable Energy", Elsevier, Academic Press, 2011.
3. Peter Gevorkian, "Sustainable Energy Systems Engineering," McGraw Hill,2007.
4. Sukhatme S.P., "Solar Energy", Tata McGraw Hill, 1984.
5. Twidell J.W. and Weir A., "Renewable Energy Sources", EFN Spon Ltd., 1986.
6. Veziroglu T.N., Alternative Energy Sources", Vol 5 and 6, McGraw-Hill, 1990.
7. Kishore V.V.N., "Renewable Energy Engineering and Technology", Teri Press, New Delhi, 2012 8.Godfrey Boyle, "Renewable Energy Power for a Sustainable Future", Oxford University Press, U.K, 1996.

Open Elective Course – II					
Electrochemical Engineering					
COURSE OUTLINE					
Course Title:	**Electrochemical Engineering**	**Short Title:**	**ECE**	**Course Code:**	

Course description:

This course provides an introduction to Review Basics Of Electrochemistry, Mass Transfer In Electrochemical Systems, Corrosion, Solar Coatings, Types Of Electrochemical Reactors, Batch Cell, Fluidized Bed and Electrochemical Reactor.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics, Mathematics I and II, Basic Electrical and Electronics Engineering

Course objectives:

1. To understand basics of electrochemistry aspects.
2. To accustom about Production, Storage, Distribution and Utilization of Electrochemical Energy.
3. To apply the Electro Deposition –Electro Refining –Electroforming knowledge.
4. To understand Electrodes Used In Different Electrochemical Industries.
5. To accustom about Corrosion, Corrosion Theories and corrosion control.

Course outcomes:

After successful completion of this course the student will be able to:

1. Integrate Professional, Ethical, Social And Environmental Factors In Electrochemical Engineering Design.
2. Analyze Basics of electrochemistry aspects.
3. Apply Electro Deposition –Electro Refining –Electroforming knowledge.
4. Analyze Corrosion, Corrosion Theories and corrosion control.
5. Demonstrate Electrodes Used In Different Electrochemical Industries.

COURSE CONTENT

Electrochemical Engineering		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Review Basics Of Electrochemistry: Faraday's Law -Nernst Potential –Galvanic Cells – Polarography, The Electrical Double Layer: It's Role In Electrochemical Processes –Electro Capillary Curve –Helmoltz Layer –Guoy –Steven's Layer – Fields At The Interface

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Mass Transfer In Electrochemical Systems: Diffusion Controlled Electrochemical Reaction – The Importance Of Convention And The Concept Of Limiting Current. Over Potential, Primary-Secondary Current Distribution –Rotating Disc Electrode

Unit–III:	No. of Lectures: 09 Hours	Marks: 12
Introduction To Corrosion, Series, Corrosion Theories Derivation Of Potential current Relations Of Activities Controlled And Diffusion Controlled Corrosion Process. Potential-PH Diagram, Forms Of Corrosion- Definition, Factors And Control Methods Of Various Forms Of Corrosion-Corrosion Control Measures Industrial Boiler Water Corrosion Control – Protective Coatings –Vapor Phase Inhibitors –Cathodic Protection, Sacrificial Anodes –Paint Removers		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Electro Deposition –Electro Refining –Electroforming –Electro Polishing – Anodizing – Selective Solar Coatings, Primary And Secondary Batteries –Types Of Batteries, Fuel Cells		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Electrodes Used In Different Electrochemical Industries: Metals-Graphite –Lead Dioxide – Titanium Substrate Insoluble Electrodes –Iron Oxide –Semi Conducting Type Etc. Metal Finishing-Cell Design. Types Of Electrochemical Reactors, Batch Cell, Fluidized Bed Electrochemical Reactor, Filter Press Cell, Swiss Roll Cell, Plug Flow Cell, Design Equation, Figures Of Merits Of Different Type Of Electro Chemical Reactors		

Text Books:

1. Picket, "Electrochemical Engineering ", Prentice Hall. 1977.
2. Newman, J. S., "Electrochemical Systems ", Prentice Hall, 1973.

Reference Books:

1. Barak, M. And Stevenge, U. K., "Electrochemical Power Sources – Primary and Secondary Batteries" 1980.
2. Mantell, C.," Electrochemical Engineering ", McGraw Hill, 1972.

Open Elective Course – II					
Solid Waste Management					
COURSE OUTLINE					
Course Title:	**Solid Waste Management**	**Short Title:**	**SWM**	**Course Code:**	

Course description:

The aim of this course is to understand fundamentals in solid waste management. This course provides the information about management of solid waste from municipal, industrial and agricultural sources.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Chemistry, Physics .

Course objectives:

1. To learn the collection, storage and transport of solid waste from different sources.
2. To understand pyrolysis of solid waste.
3. To learn treatment, disposal and recycling of solid waste.
4. To accustom about composting and design of mechanical composting plant.
5. To understand incineration, types, applications and theory of incinerators.

Course outcomes:

After successful completion of this course the student will be able to:

1. Analyze the sources, types and characterization of solid waste.
2. Apply the methods of collection, storage and transport of solid waste
3. Understand the various treatment methods and disposal of solid waste.
4. Apply composting theory in design of mechanical composting plant.
5. Analyze incineration, types, applications and theory of incinerators in incineration plants.

COURSE CONTENT

Solid Waste Management		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Origin of solids waste, Bad effect of solid waste, history of solid waste management, Refuse analysis, composition and quantity of refuse, and transportation of refuse. Origin of solid waste to industries, common type of solid wastes, collection and transportation

Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**

Solid waste handling methods, segregation and salvage, Recovery of bye-products, use of solid waste as raw materials in industry. Sampling plan for domestic solid waste, IS Specifications for collection bins, Methods of collection, Multiple bin collection system, Sanitary Landfill, Site selection, methods, procedures and precautions. Leach ate and contamination of water Bearing strata. Economic aspects of refuse collection

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Composting-theory of composting, types of composting, factors governing composting, Design of mechanical Composting plant, Recovery of Bio Gas energy from organic solid waste, Vermi composting.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Incineration, Necessity, Applications, Theory, Types of incinerators. Location, planning aspect. Effect of feed, composition, rate and temperature, Air supply. Concept of 3R.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Pyrolysis and it's by products, Air Pollution due to incineration. Status of solid waste management in India. Cost economics of solid waste management, Thermal power plant solid waste- reuse and disposal, Hospital solid waste collection and disposal, Market waste.		
Text Books:		
1. A.D. Bhide, B B Sudarsen, Solid Waste Management in Developing Countries, Indian National Scientific Documentation Centre Publication. 2. Frank Flintoff, Management of Solid Waste in Developing Countries, WHO Publication.		
Reference Book:		
George Tchobanoglous, Frank Kreith, Hand Book of Solid Waste Management, McGraw Hill New Delhi.		

Open Elective Course – II					
Biotechnology					
COURSE OUTLINE					
Course Title:	**Biotechnology**	**Short Title:**	**BT**	**Course Code:**	

Course description:

The intent of this course is to help to understand fundamentals in biotechnology. The course aims to provide understanding of the core principles and topics of Biotechnology and to enable students to acquire a specialized knowledge.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Biology

Course objectives:

1. To understand basic principles and concepts of biological sciences.
2. To learn tools of rDNA Technology, making recombinant DNA, DNA Library.
3. To learn proteins, structure function relationship in proteins, purification and Characterization of proteins.
4. To understand genome sequencing projects, gene prediction, Genome similarity and , types of genomics.
5. To learn cell, tissue culture techniques and applications.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand and apply fundamental biological principles from the major areas of biology.
2. Apply tools of rDNA Technology, making recombinant DNA.
3. Analyze proteins, structure function relationship in proteins, purification and characterization of proteins.
4. Apply genome sequencing projects, gene prediction.
5. Analyze cell, tissue culture techniques.

COURSE CONTENT

Biotechnology		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Definitions, Scope and Importance, Classical vs Modern concepts, Manufacturing quality control, Product Safety, Good manufacturing practices, Good laboratory practices, Microbial Culture Techniques, Measurement and Kinetics of Microbial Growth, Scale up of Microbial Process, Isolation of Microbial Products, Strain Isolation and Improvement, Applications of Microbial Culture Technology, Bioethics in Microbial Technology.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12
Introduction to the world of Proteins, 3-D Shape of Proteins, Structure Function relationship in Proteins, Purification of Proteins, Characterization of Proteins, Protein based products, Designing Proteins, Proteomics.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Introduction, Tools of rDNA Technology, Making Recombinant DNA, DNA Library, Introduction of Recombinant DNA into host cells, Identification of Recombinants, Polymerase Chain Reaction (PCR), DNA Probes, Hybridization Techniques, DNA Sequencing, Site-directed mutagenesis.		
Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**
Introduction, Genome Sequencing Projects, Gene prediction and Counting, Genome similarity, SNPs and comparative genomics, Functional Genomics, History of Bioinformatics, Sequences and Nomenclature, Information Sources, Analysis using Bioinformatics tools.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Introduction, Cell and Tissue Culture Techniques, Applications of Cell and Tissue Culture, Gene Transfer Methods in Plants, Transgenic Plants with Beneficial Traits, Animal Cell Culture Techniques, Characterization of Cell Lines, Scale-up of Animal Culture, Process, Applications of Animal Cell Culture		

Text Books:

P. K Gupta, Introduction to Biotechnology, Rastogi Publications.

Reference Books:

1. Smith, Biotechnology, Cambridge Press.
2. Doran PM, Bioprocess Engineering Principles (1995), Academic Press Ltd, USA
3. C.F. Bryce,D. Balasubramanian, Concepts in Biotechnology, Universities Press.
4. Thieman, W.J. and M.A. Palladino, Introduction to Biotechnology, 3rd edition. Pearson / Benjamin Cummings.

Mass Transfer-II Lab					
LAB COURSE OUTLINE					
Course Title:	**Mass Transfer-II Lab**	**Short Title:**	**MT-II Lab**	**Course Code:**	

Course description:

This course aims to apply principle and theory of diffusion to various Mass Transfer operations. It helps to understand, operate various equipments and gain practical knowledge of Mass Transfer phenomenon through experimentation.

Laboratory	Hours/week	No. of weeks	Total hours	Semester credits
	2	14	28	1

End Semester Exam (ESE) Pattern:	Practical (PR)

Prerequisite course(s):

Mass Transfer-I, Mass Transfer-I Lab.

Course objectives:

1. To impart design skills, both in analysis and synthesis.
2. To define driving potential for mass transfer as concentration gradient, and to verify for various mass transfer operations.
3. To understand and develop process replica of experiments performed.
4. To display the research by designing, conducting, interpreting and analyzing experimental data for preparing reports
5. To demonstrate the understanding of professional and ethical responsibilities.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Display skill of the theoretical principles and practical considerations for design and operation of mass transfer operations, processes.
2. Understand the engineering approaches to deriving the design equations for complex mass transfer operations.
3. Identify design requirement and predict the major process parameters in separation processes.
4. Analyze experimental data to derive the kinetic and process parameters with simple computing techniques.
5. Understand the environmental issues and to provide solutions for green and clean technologies.

LAB COURSE CONTENT

Mass Transfer-II Lab		Semester:	VI
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**End semester exam (ESE):**	**25 marks**
		Internal Continuous Assessment (ICA):	**25 marks**

(Amongst the following any eight experiments / assignments are to be performed)

1. Simple Distillation: To verify Rayleigh's equation for simple distillation.
2. To plot the vapor liquid equilibrium curve for a binary mixture.
3. Determination of HTU, HETP and NTU.
4. Ternary Diagram: To construct ternary diagram for given system.

5. Tie Lines.
6. Liquid – Liquid Extraction: To study and determine the efficiency of cross current liquid-liquid extraction.
7. Spray Column.
8. Leaching: To calculate efficiency of cross current leaching operation.
9. Adsorption: To study adsorption of acetic acid on activated charcoal.
10. Ion Exchange.

Text Books:

1. Coulson & Richardson Chemical Engineering (Vol. II), Butterworth-Heinmann (Elsevier) (Fifth Edition).
2. Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers.

Reference Book:

R.E.Treybal, Mass transfer operation, McGraw Hill Book Company, (Third Edition).

Guide lines for ICA:

Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal.

Guidelines for ESE:

End Semester Examination shall be based on practical / oral evaluation of Student performance and practical / assignments submitted by the student in the form of journal.

Chemical Reaction Engineering-II Lab					
LAB COURSE OUTLINE					
Course Title:	**Chemical Reaction Engineering-II Lab**	**Short Title:**	**CRE-II Lab**	**Course Code:**	

Course description:

The intent of this course is to help to understand concepts in chemical reaction engineering. This course describes experimental techniques for determining rate for heterogeneous chemical reactions, the mechanisms and theories of heterogeneous chemical reactions.

Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	2	14	28	1

End Semester Exam (ESE) Pattern:	**Oral (OR)**

Prerequisite course(s):

Chemistry Lab, Mass Transfer I and II Lab.

Course objectives:

1. To accustom with heterogeneous reactions.
2. To introduce and enhance the rate of non catalytic heterogeneous chemical reactions.
3. To understand improvement in purity of ethanol using various reactive and extractive distillation.
4. To apply absorption and adsorption processes for heterogeneous systems.
5. To analyze & interpret data obtained during performance of the experiment.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Demonstrate about how enhance the rate of non catalytic heterogeneous chemical reactions.
2. Display skill of improvement in purity of ethanol using various reactive and extractive distillations.
3. Identify, formulate, design and provide the solution to absorption and adsorption processes for heterogeneous systems various.
4. Exhibit the understanding of professional and ethical responsibilities.
5. Understand the environmental issues and to provide solutions for green and clean technologies.

LAB COURSE CONTENT

Chemical Reaction Engineering-II Lab		**Semester:**	**IV**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**End semester exam (ESE):**	**25 marks**
		Internal Continuous Assessment (ICA):	**25 marks**

(Amongst the following any eight experiments / assignments are to be performed)

List of Experiments/Assignments:

1. To study the reaction of solid liquid system for an instantaneous reaction for benzoic acid NaOH and calculate the enhancement factor.
2. To study the isothermal decomposition of ethyl alcohol in tubular reactor packed with activated alumina catalyst.
3. To improve the % purity of commercially used ethanol using reactive distillation.

4. To improve the % purity of commercially used ethanol using extractive distillation.
5. To carry out the catalytic reaction to convert the nitrobenzene to aniline in presence of iron filling / HCl catalyst in the reactor.
6. To study the reaction of liquid-liquid system for butyl acetate - NaOH and to calculate the enhancement factor.
7. Absorption – to study the reaction of liquid gas system for NaOH – CO2 to determine rate of absorption.
8. Adsorption – to study the adsorption of Acetic Acid on charcoal.
9. Preparation of Butyl Acetate by Reactive Esterification.

Text Books:

1. Octave Levenspiel, Chemical Reaction Engineering, John Wiley and Sons.
2. Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers.

Reference Book:

H. Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall New Jersey.

Guide lines for ICA:

Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal.

Guidelines for ESE:

End Semester Examination shall be based on practical / oral evaluation of Student performance and practical / assignments submitted by the student in the form of journal.

Heat Transfer Lab

LAB COURSE OUTLINE

Course Title:	Heat Transfer Lab	Short Title:	HT Lab	Course Code:	

Course description:

This course illustrates practical aspect of heat transfer and its application to chemical engineering. It describes various modes of heat transfer and mechanism responsible for heat transmission. It helps the students to understand various equipments used in industries.

Laboratory	Hours/week	No. of weeks	Total hours	Semester credits
	2	14	28	1

Prerequisite course(s):

Physics, Chemistry I and II.

Course objectives:

1. To learn how to determine thermal conductivity of metal rods and heat flux through composite wall.
2. To accustom calculation of heat transfer coefficient and fin efficiency in natural / forced convection.
3. To understand determination of emissivity and Stefan Boltzmann Constant.
4. To inculcate caliber of consideration about LMTD and overall heat transfer coefficient.
5. To identify, formulate, design and provide the solution to various chemical engineering problems.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Determine thermal conductivity of metal rods and heat flux through composite wall.
2. Apply skill of calculation of heat transfer coefficient and fin efficiency in natural / forced convection.
3. Demonstrate determination of emissivity and Stefan Boltzmann Constant.
4. Display caliber of consideration about LMTD and overall heat transfer coefficient.
5. Demonstrate the understanding of professional and ethical responsibilities.

LAB COURSE CONTENT

Heat Transfer Lab		Semester:	IV
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA):**	**25 marks**

(Amongst the following any eight experiments / assignments are to be performed)

1. Determination of thermal conductivity of metals rod.
2. To determine heat flux through composite walls.
3. Determination of heat transfer coefficient in natural/ forced convection.
4. Determination of temperature distribution, fin efficiency in natural and forced convection.
5. Determination of emissivity of a test surface.
6. Determination of Stefan Boltzmann constant.
7. Determinations of log mean temperature difference and over all heat transfer coefficient of Parallel and counter flow heat exchanger.
8. Heat transfer through lagged pipe.

9. Study of heat transfer in evaporator. 10. To find out overall heat transfer coefficient by drop wise and film wise condensation.
Text Book:
Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers.
Reference Book:
Prof. Addul Matheen, Heat Transfer laboratory Manual (Second Edition), University Science Press.
Guide lines for ICA:
Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal.
Guidelines for ESE:
NA

Minor Project

LAB COURSE OUTLINE

Course Title:	**Minor Project**	**Short Title:**	**MPROJ**	**Course Code:**	

Course description:

Minor project represent the culmination of study towards the Bachelor of Engineering degree. The minor project offers the opportunity to apply and extend material learned throughout the program. The emphasis is necessarily on facilitating student learning in technical, project management and presentation spheres.

Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	6	**14**	**84**	**3**

End Semester Exam (ESE) Pattern: **Oral (OR)**

Prerequisite course(s):

Course objectives:

1. To understand the basic concepts & broad principles of projects.
2. To understand the value of achieving perfection in project implementation & completion.
3. To apply the theoretical concepts to solve problems with teamwork and multidisciplinary approach.
4. To demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context.
5. To develop ability of extracting the material from the different sources and writing comprehensively and exhaustive report on an allotted topic.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Demonstrate a sound technical knowledge of their selected project topic.
2. Undertake problem identification, formulation and solution.
3. Identify, formulate, design and provide the solution to various chemical engineering problems.
4. Conduct an engineering project.
5. Demonstrate the knowledge, skills and attitudes of a professional engineer.

LAB COURSE CONTENT

Minor Project		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme:**	
Practical:	**6 hours/week**	**End semester exam (ESE): (OR)**	**25 marks**
		Internal Continuous Assessment (ICA):	**50 marks**

The Minor Project, in continuation with Minor Project (Stage – I) at Semester – V, by the end of Semester – VI, the student should complete implementation of ideas as formulated in Minor Project (Stage – I).
The project may be either fully theoretical / practical or involving both theoretical and practical work to be assigned by the Department. The work may also be Study / Survey / Design. Each student group should submit complete project report at the end of Semester-VI in the form of Hard bound. Assessment for the project shall also include presentation by the students.

Each student group is required to maintain separate log book for documenting various activities of the project.

Suggestive outline for the complete project report is as follows.

Abstract

Chapter 1. Introduction

Chapter 2. Literature Survey

Chapter 3. Methodology

Chapter 4. Results & Discussion

Chapter 5. Conclusion

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Appendix

Guide lines for ICA:

The Internal Continuous Assessment (ICA) for project shall be based on continuous evaluation of students' performance, active participation, knowledge / skill acquired throughout semester and presentation by the students. The assessment shall be done jointly by the guide and departmental committee. A three-member departmental committee including guide, appointed by Head of the department, shall be constituted for the assessment. The assessment for Minor Project in Semester – VI shall be as per the guidelines given in Table – B.

Table – B

		Assessment by Guide				Assessment by Departmental Committee			
Sr. No.	Name of the Student	Attendance / Participation	Implementation	Results	Report	Depth of Understanding	Presentation	Demonstration	Total
	Marks	5	5	5	5	10	10	10	50

Guidelines for ESE:

In End Semester Examination (ESE), the student may be asked for presentation / demonstration and questions on Project. Evaluation will be based on answers given by students in oral examination.

Internship

Internship is a mandatory and non-credit course. It is mandatory for all admitted students to undergo Internship during the degree course. The course shall be of THREE weeks duration during summer vacation after Semester - VI. Following are the intended objectives of internship training:

- Will expose Technical students to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Experience gained from the 'Industrial Internship' will be used in classroom discussions.
- Create conditions conducive to quest for knowledge and its applicability on the job.

Students shall choose to undergo Internship / Innovation / Entrepreneurship related activities for Internship. Students shall choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo internship with industry/ NGO's/ Government organizations / Micro / Small / Medium enterprises / academic institutions / research institutions. In case student want to pursue their family business and don't want to undergo internship, a declaration by a parent may be submitted directly to the Department Head / TPO.

During the last year of FOUR year Bachelor of Engineering course the student should take project work, as specified in the curriculum, based on the knowledge acquired by the student during the degree course and during Internship. The project work provides an opportunity to build a system based on area where the student likes to acquire specialized skills. The work may also be on specified task or project assigned to the student during Internship.

The internship activities and list of sub-activities for Internship are as under.

- Innovation / Entrepreneurship:
    - Participation in innovation related Competitions for eg. Hackathons Robocon, Baha, IIT Tech Fest, Chemcon, Dipex etc
    - Development of new product/ Business Plan/ registration of start-up
    - Participation in Entrepreneurship Program of THREE weeks duration
    - Online certification courses by SWAYAM, NPTEL, and QEEE etc.
    - Working for consultancy/ research project within the institutes
    - Training on Software (As per the need of respective branch);
    - Field Survey / Case Study
    - Work experience at family business
- Internship:
    - Internship with Industry /Govt. / NGO/ PSU/ Any Micro/ Small/ Medium enterprise/ academic institutions / research institutions
    - Online Internship
- Rural Internship
    - Any Long Term Goals may be carried out by students in teams:
        - Prepare and implement plan to create local job opportunities.

- Prepare and implement plan to improve education quality in village.
- Prepare an actionable DPR for doubling the village Income.
- Developing Sustainable Water Management system.
- Prepare and improve a plan to improve health parameters of villagers.
- Developing and implementing of Low Cost Sanitation facilities.
- Prepare and implement plan to promote Local Tourism through Innovative Approaches.
- Implement/Develop Technology solutions which will improve quality of life.
- Prepare and implement solution for energy conservation.
- Prepare and implement plan to Skill village youth and provide employment.
- Develop localized techniques for Reduction in construction Cost.
- Prepare and implement plan of sustainable growth of village.
- Setting of Information imparting club for women leading to contribution in social and economic issues.
- Developing and managing efficient garbage disposable system.
- Contribution to any national level initiative of Government of India. For eg. Digital India/ Skill India/ Swachh Bharat Internship etc.

Faculty Mentor/Supervisors have to play active roles during the internship and minimum 20 students are to be supervised by each faculty mentor or as per the departmental strength. Mentor shall be responsible for selection of Internship activities by the student under his/her supervision and shall avoid repetition of activities by the student. The college / Institute shall facilitate internship for the students.

Every student is required to prepare a file for Internship containing documentary proofs (daily training diary, comprehensive report and completion certificate) of the activities done by him/her. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should include Date, Time of Arrival, Time of Departure, Main points of the day. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working.

After completion of Internship, the student should prepare a comprehensive report to indicate what he / she has observed and learnt in the training period. The report should include Internship Objectives (in measurable terms), Internship Activities, and Internship Outcome.

The completion certificate should be signed by the supervisor / in charge of the section where the student has been working with performance remark as Satisfactory / Good / Excellent.

The evaluation of Internship shall be in Semester – VII. The evaluation shall be done by expert committee constituted by the concerned department including Department Head/ TPO/ faculty mentor or guide. It should be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary.
- Adequacy & quality of information recorded.
- Originality.
- Adequacy and purposeful write-up.

- Practical applications, relationships with basic theory and concepts taught in the course.
- Skill / knowledge acquired

Hence the satisfactory completion of Internship shall be submitted to the university at the end of Semester - VIII of FOUR year Bachelor of Engineering course. Only after successfully completion of Internship, Internship should be printed in the final year mark sheet as COMPLETED.